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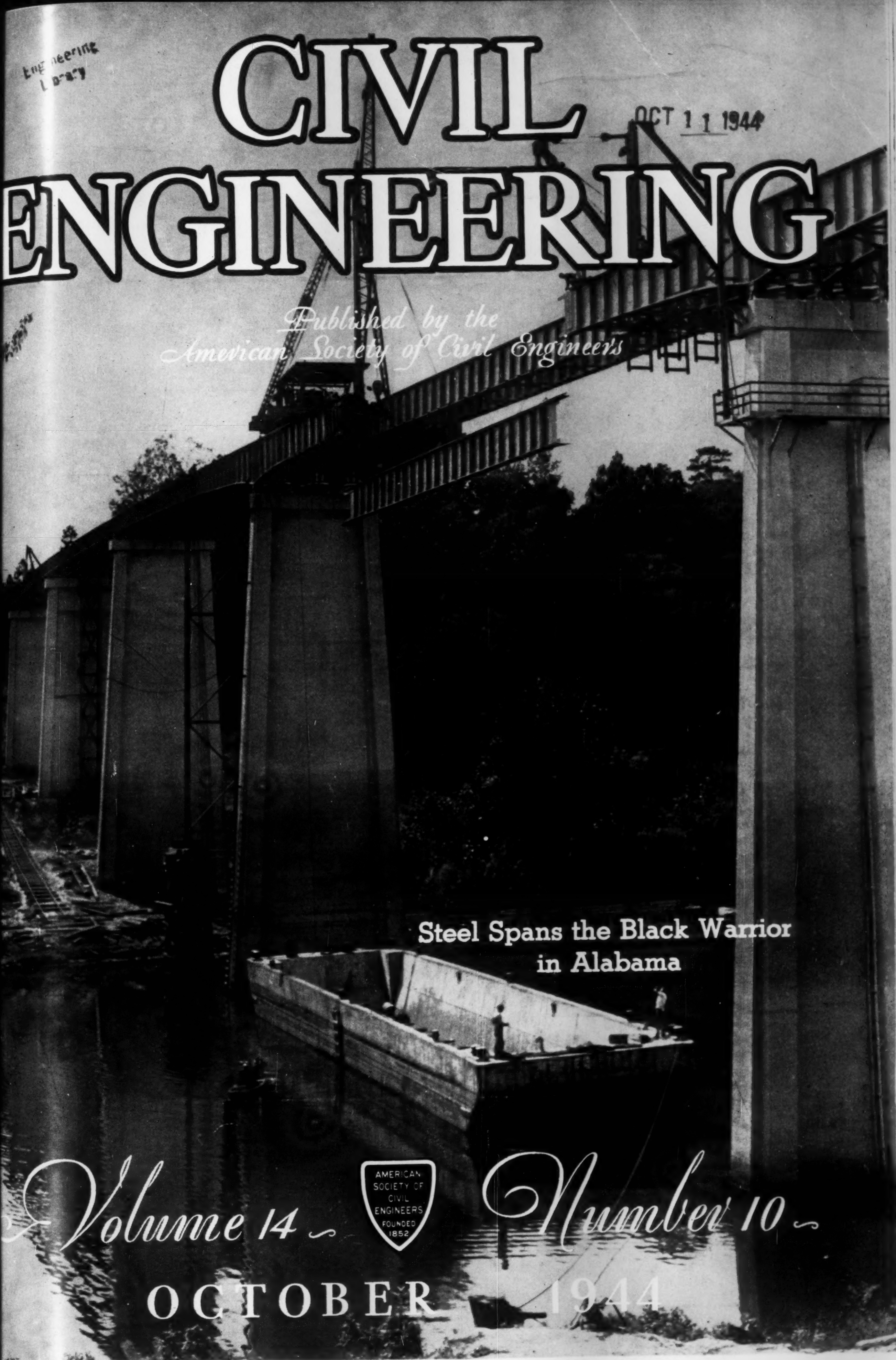

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Volume 14 Number 10

OCTOBER 1944

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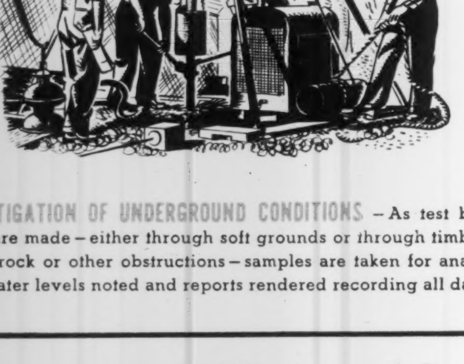

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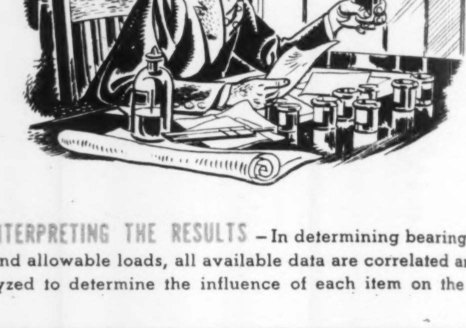

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This Issue Contains

Cover: Bridge at Foster's Ferry, Ala. (*See article page 417*)

Flood Control Plans for the Missouri River 413
R. C. Crawford

High-Level Bridge at Foster's Ferry, Ala. 417
William N. Woodbury, Donald A. du Plantier, and Edward C. Jacob

Facts and Figures on Construction Trends. I. Economic Factors Affecting Engineering and Construction Employment. 421
Elsie Eaves

Development of River Measurement Equipment 425
John C. Hoyt

Basic Hydraulics of Water Storage Projects. III. Spillways, Outlets, and Surge Tanks 428
George R. Rich

Engineering Aspects of Mosquito Control. I. Anti-Malaria Program of the Tennessee Valley Authority . . . 431
W. G. Stromquist

Peru's Ocean-to-Amazon Highway. 435
Julian L. Schley

Do Rivets Retain Their Initial Tension? 437
Wilbur M. Wilson

Omaha Airport Runways Resist Flood Damage 439
W. H. Campen and J. R. Smith

Engineers' Notebook
Rational Design of Spaced Timber Columns 441
Charles Mackintosh

Bending Moments in the Foundation Slabs of a Granary . . . 442
Paul Nemenyi

Our Readers Say. 443
Society Affairs 445
Student Chapter Annual Reports 449
Items of Interest 451
News of Engineers 453
Deceased 454
Changes in Membership Grades. 14
Applications for Admission and Transfer 18
Engineering Societies' Personnel Service 24
Recent Books 24
Current Periodical Literature 26, 28
Catalog Digests 30, 32, 34, 36, 38, 40, 42, 43, 44
Index to Advertisers 48

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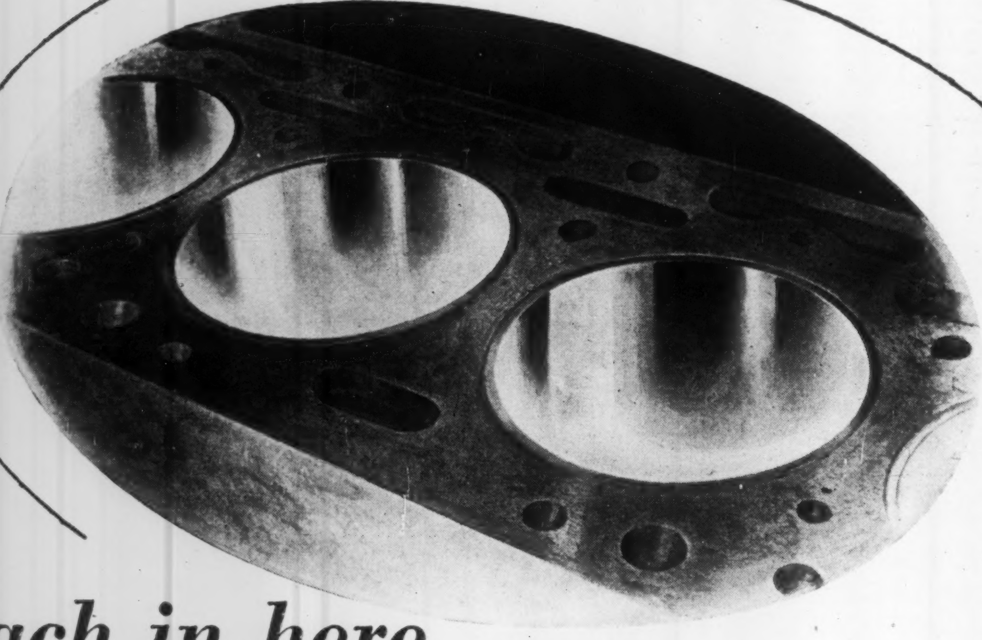

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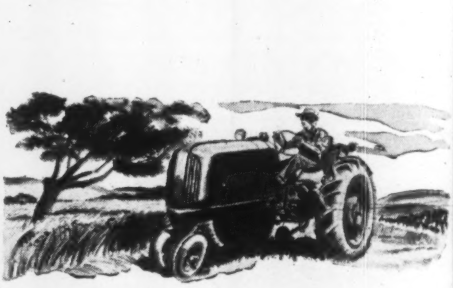

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Volume 14 October 1944 Number 10

Flood Control Plans for the Missouri River

By R. C. Crawford

Brigadier General, U.S. Army, Corps of Engineers; Division Engineer, Missouri River Division, Omaha, Nebr.

A COMPREHENSIVE plan for controlling the flow of the Missouri River is now before Congress. This "Pick Plan" provides for flood control, irrigation, navigation, power, domestic and sanitary purposes, wild life, and recreation. Included are 21 multi-purpose reservoirs and a series of levees. It is estimated that the total cost of the work will approximate 661 million dollars. This paper was presented by General Crawford at the regional Local Section meeting in St. Louis.

THE Missouri River is formed by the confluence of the Gallatin, Madison, and Jefferson rivers at Three Forks, Mont., in the southwest part of that state, whence it flows in a generally southeasterly direction to its junction with the Mississippi River, about 17 miles above St. Louis (Fig. 1). The drainage area of the basin is about 529,000 sq miles, including about 10,000 sq miles in the Dominion of Canada. It includes all the State of Nebraska and portions of Montana, Wyoming, Colorado, North Dakota, South Dakota, Minnesota, Iowa, Missouri, and Kansas. The river, from Three Forks to the mouth, is approximately 2,460 miles in length and has a fall of about 3,630 ft, or 1.5 ft per mile. The maximum and minimum discharges of record at the mouth are about 900,000 and 4,000 cu ft per sec, respectively.

The broad range in latitude and elevation over the Missouri Basin as a whole causes a wide variation in climatic conditions. The most important variation is in the matter of rainfall, a change which is especially marked in an easterly and westerly direction. The range in precipitation includes both humid and arid zones. The upper half of the main stem area, generally west of the 104th meridian, lies in the arid zone, while the area east of the 98th meridian lies in the humid zone. The average annual rainfall varies from about 10 in. in the drier portions of the arid zone to about 26 in. in the vicinity of Sioux City, and 40 in. near the mouth.

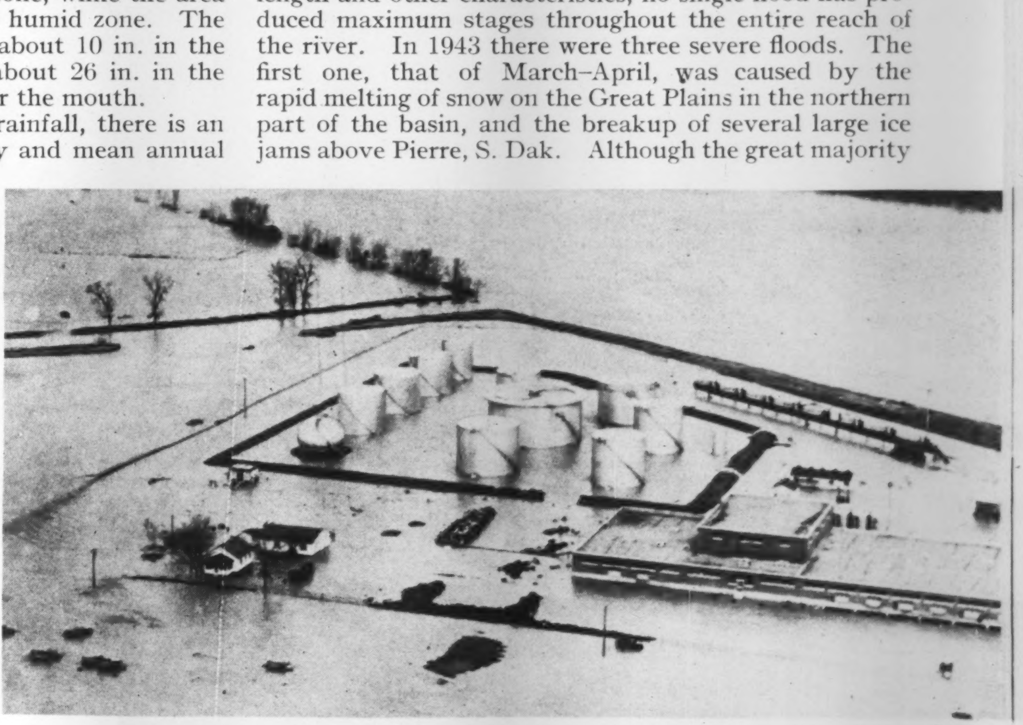
In addition to the wide range in rainfall, there is an equally wide range in mean monthly and mean annual temperatures. The annual mean varies from about 38 F in northeastern Montana to 56 F at St. Louis. Thus the Missouri River, with its tributaries rising at elevations as great as 12,500 ft at the headwaters of the South Platte in Colorado, and flowing into the Mississippi River at an elevation of about 400 ft, passes through probably more diverse terrain than any other major river in the United States. The problems of its control and utilization are obviously not simplified by this wide range in elevation, climate, rainfall, and topography.

Each year the Missouri is subject to two general periods of high water. These are often referred to as the "March rise" and the "June rise." The former is caused by the rapid melting of snow in the plains of Montana, Wyoming, and the Dakotas, and the breakup and melting of ice on the main stem and its tributaries. The resulting floods are usually most severe along the upper part of the river.

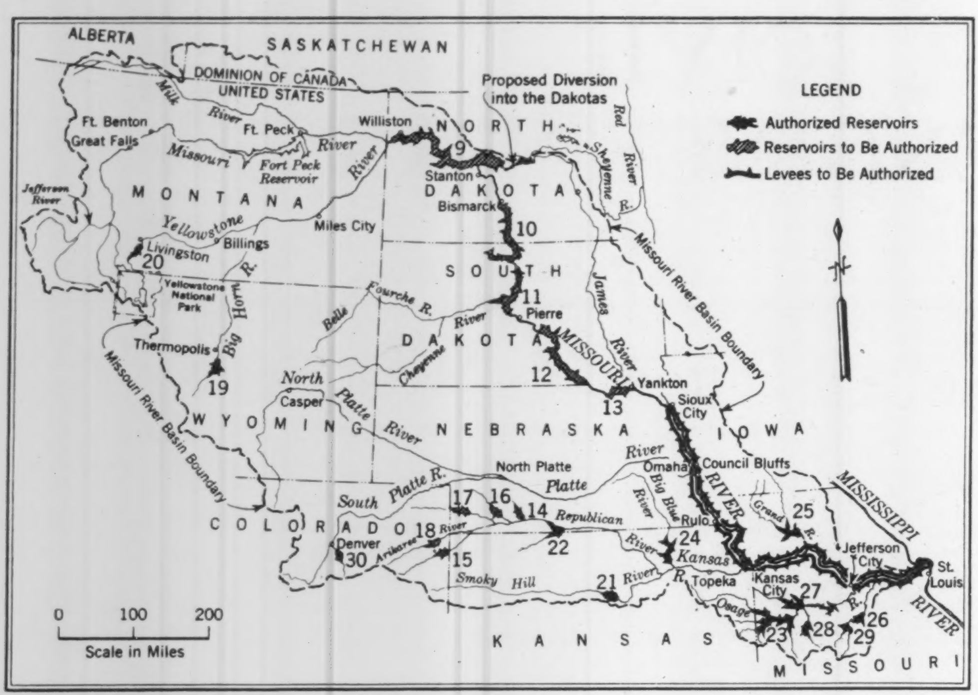
The second general period of high water, the "June rise," is produced by the combined runoff from the melting of snow in the mountains of the headwater regions, and heavy rainfall in the middle and lower basin. Floods from this rise are ordinarily most severe in the lower part of the basin, where rainfall is normally the greatest.

In addition the valley is subject to flash floods which occur at various times during the year. Many of these reach major proportions for considerable distances along the main river and usually are the result of heavy runoff from local tributaries or from local ice jams. Practically every year there is some flooding of this character.

There have been 12 major floods of record on the Missouri in the past 100 years. Because of its great length and other characteristics, no single flood has produced maximum stages throughout the entire reach of the river. In 1943 there were three severe floods. The first one, that of March–April, was caused by the rapid melting of snow on the Great Plains in the northern part of the basin, and the breakup of several large ice jams above Pierre, S. Dak. Although the great majority



Petroleum Products Plant at East Omaha, Nebr., Inundated by April 1943 Flood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Proposed Diversion into the Dakotas
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Authorized Reservoirs
Reservoirs to Be Authorized
Levees to Be Authorized
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Ft. Benton
Great Falls
Ft. Peck
Missouri River
Fort Peck Reservoir
Jefferson River
Williston
NORTH DAKOTA
Stanton
Bismarck
Red River
Sheyenne R.
MONTANA
Yellowstone
Billings
Miles City
Livingston
Yellowstone National Park
Big Horn R.
Thermopolis
SOUTH DAKOTA
Belle Fourche R.
Pierre
Cheyenne River
James River
Missouri River Basin Boundary
MISSOURI RIVER
Yankton
Sioux City
IOWA
North Platte River
Casper
WYOMING
NEBRASKA
North Platte
Platte River
Omaha
Council Bluffs
Big Blue River
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MISSISSIPPI RIVER
Grand R.
Jefferson City
St. Louis
South Platte R.
Republican River
Arikaree River
COLORADO
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FIG. 1. MISSOURI RIVER WATERSHED, WITH FLOOD CONTROL PROJECTS

of the snow melt contributing to this flood occurred below the Fort Peck Dam in Montana, the reservoir reduced stages perceptibly along the entire main stem, ranging from about 3 ft at Bismarck, N. Dak., to 2 ft at Kansas City, and 1 ft at St. Louis.

The next flood was caused by two protracted periods of heavy rainfall during the month of May over the basins of the Grand, Osage, and Gasconade rivers—the first from May 6 to 11, and the second from May 15 to 20. The latter produced the heaviest precipitation, which amounted to about $4^1/_2$ in. over the Grand Basin, nearly 7 in. over the Osage Valley, and about 5 in. over the Gasconade Basin. These two periods of rainfall raised the main stream between the mouth of the Osage and St. Charles, Mo., to the highest general levels since 1844.

TABLE I. AUTHORIZED RESERVOIR PROJECTS

Project	Location	Height Above Stream Bed, Ft	Approx. Gross Storage Capacity, Acre-Ft	Approx. Total Construction Cost
Kanopolis (21)	Smoky Hill River near Ellsworth, Kans.	125	450,000	$ 9,000,000
Harlan County (22)	Republican River, Harlan County, Nebr.	115	850,000*	31,000,000
Tuttle Creek (24)	Big Blue River near Manhattan, Kans.	142	1,470,000	28,000,000
Chillicothe (25)	Grand River near Chillicothe, Mo.	73	1,520,000	28,500,000
Arlington (26)	Gasconade River at Arlington, Mo.	133	770,000	7,300,000
Richland (29)	Gasconade River near Richland, Mo.	134	600,000	6,900,000
Osceola (23)	Osage River near Osceola, Mo.	101	4,500,000	28,500,000
South Grand (27)	South Grand River near Warsaw, Mo.	106	1,120,000	10,400,000
Pomme de Terre (28)	Pomme de Terre River near Hermitage, Mo.	110	480,000	6,200,000
Totals			11,760,000	$155,800,000

* 150,000 acre-ft allocated to irrigation use.

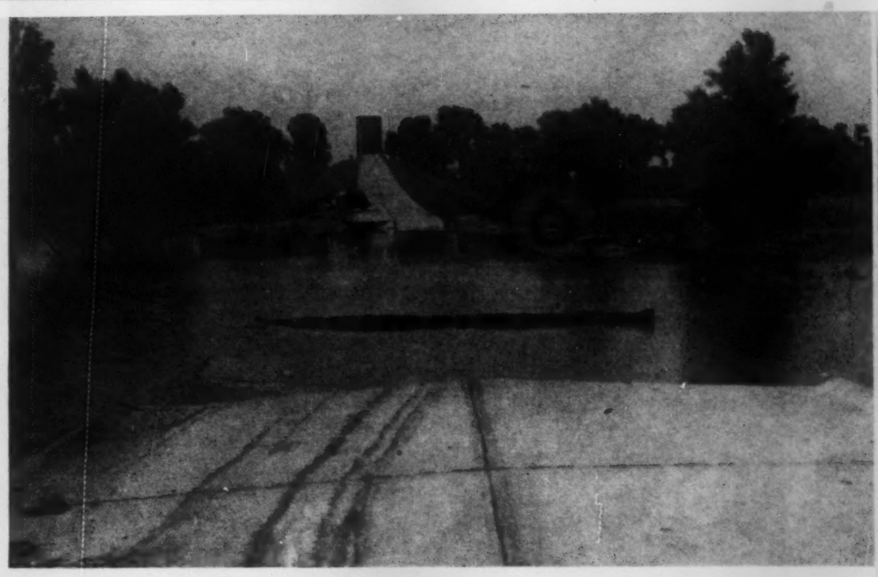
As for the third flood of the year, it was the result of heavy rains over southeast Nebraska, southwest Iowa, northwest Missouri, and north-central and northeast Kansas on June 8, 10, 11, and on June 15 and 16. Precipitation over this area during these five days averaged from 6 to 7 in. and at some stations amounted to as much as 7 in. a day. During the resulting flood, the peak runoff from the rains of June 15 and 16 coincided with the arrival at Kansas City of a rise from the melted snows of the Yellowstone River augmented by rain-swollen tributaries of the main river in the Dakotas and northern Nebraska. During this flood, the river reached the highest stages since 1917 at St. Joseph, Mo., and generally the highest levels since 1903 from Kansas City to the mouth of the Osage. Although this was essentially a down-river flood, the effect of the Fort Peck Reservoir was again noticeable. It reduced crest stages about $2^1/_2$ ft at St. Joseph, $1^1/_2$ ft at Kansas City, and nearly 1 ft at Hermann, Mo.

It is worthy of note that the high water of March–April 1943 was the first major flood of record between Sioux City and Kansas City in which no cutoffs and no changes in the main channel of the river occurred. This keeping of the river within its pre-flood channel was made possible by the dikes, revetments, and other improvements for navigation. There were also no cutoffs or channel changes during the May and June floods.

These three 1943 floods covered over 2,000,000 acres of farm land and caused direct damages estimated at $40,000,000. Indirect damages totaled about $7,800,000, and 11 lives were lost. In addition to many serious interruptions to railroad and highway services, and to important war production and other industry in the basin, there was a very definite loss of valuable food. About $25,000,000 of the total direct damages of $40,000,000 was made up of actual crop losses.

During these three floods the Engineer Department made every effort to hold damages and loss of life to a minimum. Engineer Department employees and soldiers worked over 660,000 man-hours in flood fighting and rescue work. Such emergency work by the department and by local people prevented the flooding of about 112,000 acres of farm land and greatly reduced the damage to railroads, highways, and other installations such as the access road from St. Louis to the Weldon Spring Ordnance Plant, the St. Charles Water Works, the St. Louis County Water Works, and the Kansas City Airport. The flood damage at Kansas City has been estimated at about $130,000. Had it not been for the emergency work at this point, several million dollars worth of damage would have occurred.

As a result of the March–April flood, local interests in the spring of 1943 asked for a restudy of the flood problem on the Missouri. This resulted in a Congressional resolution dated May 13, 1943, calling upon the Engineer Department to review its previous reports on the Missouri with a view to determining whether any modi-



Section of Highway near Kansas City, Mo., Washed Out by June 1943 Flood

fications should be made with respect to flood control along the main stem from Sioux City, Iowa, to the mouth. The report of the investigation called for by this resolution was completed by the Missouri River Division Office under the direction of Brig. Gen. Lewis A. Pick on August 10, 1943, and is now (September 1, 1944) before Congress for action. This report is based on the lessons learned by the Missouri River Division during the floods of 1943, and on the large volume of factual data contained in the "308" report on the Missouri River and in numerous other reports on the tributaries.

The 1943 report, frequently called the "Pick Plan," proposes a comprehensive plan for the Missouri River Basin which, in addition to providing flood control benefits on the Missouri and Mississippi rivers, would also provide for the most efficient utilization of the waters of the basin for all purposes, including irrigation, navigation, power, domestic and sanitary purposes, wild life, and recreation. It was developed by expanding the program of federal flood control projects already authorized by Congress for the basin.

These authorized projects, which directly affect the flood flows of the Missouri River, are as follows: (1) 9 reservoir projects in the states of Missouri, Kansas, and Nebraska; (2) a project for the protection of the Kansas Citys; and (3) a levee project for the protection of agricultural lands along the Missouri between Sioux City and Kansas City. To these might be added the Fort Peck Reservoir, which was authorized primarily for navigation but contributes materially to flood control, as has been pointed out. This dam, a hydraulic-fill structure 250 ft high, was essentially completed in 1939 at a cost of $120,000,000 and creates a reservoir of 19,400,000 acre-ft capacity.

The 9 reservoir projects already authorized are shown in Fig. 1, and listed in Table I. Of these projects, construction had been initiated on only one—the Kanopolis Reservoir—before the war. When work was suspended it was about 60% complete.

The project for the protection of the Kansas Citys was authorized in the Flood Control Act of 1936, which provided for the expenditure of $10,000,000. A report based on continued investigations and studies, also authorized in the Flood Control Act of 1936, was recently submitted to Congress by the Secretary of War. This report recommends a flood plan for the Kansas Citys providing for levees, flood walls, the raising and lengthening of bridges, moving back of the levee along the Missouri River in North Kansas City, and the construction of a cutoff across Liberty Bend on the river downstream from Kansas City. Over $2,500,000 of federal funds have been expended thus far on this project in the construction of a levee and flood wall around the Fairfax industrial center of Kansas City, Kans., and in clearing the channel of the Kansas River at its mouth. The estimated cost of the remainder of this project is $13,000,000 of federal funds and $2,200,000 of non-federal funds for rights of way and relocations. The levees and flood walls for the project are designed to pass the flood flows as reduced by the proposed upstream reservoirs.

The levee project for the protection of agricultural lands between Sioux City and Kansas City was authorized in the Flood Control Act of 1941. It provided for protection against discharges similar to those which occurred during the 1938 flood. No work was ever done on this project because of the war. The plans for these levees were reviewed under the Resolution of May 13, 1943, and as a result of the review higher levees, with protection against greater discharge, are now recommended.

In addition to the projects just described, there are a number of other authorized projects on tributaries of the Missouri which do not directly affect the flood flows of the main stem. Probably the most important of these is the Cherry Creek Reservoir project which, when constructed, will provide complete protection to the city of Denver, Colo., against floods originating in the Cherry Creek Basin. The dam would be located about 6 miles upstream from the city limits of Denver.

LOCAL LEVEES INADEQUATE

Engineering studies show that complete protection between Sioux City and the mouth by levees alone is impracticable, even with all the presently authorized tributary reservoirs in operation. Therefore additional reservoirs must be provided. With the numerous problems of water use and control on the Missouri Basin in mind, common sense and sound economic planning dictate that these reservoirs be multiple purpose. Through such development, not only would large flood damages be prevented but flood waters would be stored and retained for their best uses for all purposes, including irrigation, navigation, power, water supply, pollution abatement, wild life conservation, and recreation.

The proposed comprehensive plan, therefore, includes the following in addition to projects already authorized: a series of levees along both sides of the main stem of the Missouri River from Sioux City to the mouth; five multiple-purpose reservoirs on the main stem above Sioux City (Table II); five multiple-purpose reservoirs on tributaries of the Republican River upstream from the

Table II. Proposed Reservoirs Above Sioux City, Iowa

Project	Stream	Location, Near	Height Above Stream Bed, Ft	Approx. Gross Storage Capacity, Acre-Ft	Approx. Total Construction Cost
Garrison (9)	Missouri	Garrison, N.D.	195	17,000,000	$130,000,000
Oak Creek (10)	Missouri	Mobridge, S.D.	135	6,000,000	60,000,000
Oahe (11)	Missouri	Pierre, S.D.	135	6,000,000	50,000,000
Ft. Randall (12)	Missouri	Wheeler, S.D.	165	6,000,000	75,000,000
Gavins Point (13)	Missouri	Yankton, S.D.	35	200,000	15,000,000
Lower Canyon (20)	Yellowstone	Livingston, Mont.	305	2,250,000	35,000,000
Boysen (19)	Big Horn	Thermopolis, Wyo.	217	3,500,000	20,000,000
Totals				40,950,000	$385,000,000

DAMAGE TO RAILROAD SUBGRADE CAUSED BY APRIL 1944 FLOOD ON MISSOURI RIVER

authorized Harlan County Reservoir (Table III); and two multiple-purpose reservoirs in the Yellowstone River Basin (Table II).

EARTH-FILL LEVEES PROPOSED

Proposed levees for protecting agricultural areas would be of earth fill, with a 10-ft crown width, and side slopes of 1 on 3 on the river side and 1 on 5 on the land side, with a 2-ft freeboard above the design flood after settlement. Drainage structures would be placed through the levees as needed to provide for interior runoff. Where required by foundation conditions or other special reasons, rolled-fill levees would be constructed. Proposed floodway widths between levees would vary from a minimum of 3,000 ft from Sioux City to Kansas City, and 5,000 ft from Kansas City to the mouth. At those places where there is a concentration of population or property values, the levees would be rolled fill, with a slope of 1 on 4 on the land side and a 3-ft freeboard above the design flood. Where space is not available for levees, concrete flood walls would be built. Floodway widths at municipal and special areas would be determined by economic considerations. The total estimated cost of the proposed levees and appurtenant works is $95,200,000, of which $10,600,000 are non-federal costs for rights of way and relocations.

Thus, the total cost of the new reservoirs, as now proposed, is $410,000,000. Including Fort Peck Reservoir, the total storage above Sioux City would amount to about 60,000,000 acre-ft, and the total storage provided for the entire basin by the presently authorized and proposed reservoirs would be about 72,000,000 acre-ft.

Briefly then, the plan including both authorized and proposed projects consists of a series of levees and appurtenant works along both sides of the main stem from Sioux City to the mouth of the river; the 9 already authorized reservoirs in Nebraska, Kansas, and Missouri; and 12 additional multiple-purpose reservoirs—7 above Sioux City and 5 in the Republican River Basin. The estimated cost of the new works proposed in this plan is $490,000,000. The estimated cost of the projects now authorized, plus the proposed revision of the plan for the Kansas Citys, totals about $171,000,000. Therefore, the total cost of the complete plan is now estimated at $661,000,000, of which $565,800,000 is for reservoirs and $95,200,000 for levees and appurtenant works.

It is of interest to note the effect which this comprehensive plan would have had on the three floods of 1943 had the proposed and authorized projects been in operation. During the March–April flood, the proposed reservoir projects above Sioux City would have reduced the actual flood stage by about 15 ft at Sioux City and Omaha, and the river would not have overflowed its natural channel between Pierre, S. Dak., and Rulo, Nebr. The reservoir projects would have handled this flood without any help from the proposed levees. During the May flood, the authorized reservoir projects in the State of Missouri would have taken over 200,000 cu ft per sec off the peak discharges in the section of the river below the mouth of the Osage, and the resulting peak discharge would have been well within the proposed levees. During the June flood, the proposed reservoir projects above Sioux City would have reduced the flood stage at Kansas City by over 3 ft. Had the authorized projects in the Kansas River Basin been in operation, they would have taken an additional 3 ft off the flood stage at Kansas City, and the peak discharge of the Missouri River in its lower reaches would have been reduced by about 200,000 cu ft per sec. Also, flooding would have been greatly reduced or entirely prevented on those tributaries of the Missouri River where the reservoir projects are located.

MULTIPLE-PURPOSE RESERVOIRS

It is fitting to point out that in addition to preventing the great loss of life and damage that resulted from the three floods of 1943, the multiple-purpose reservoir projects of this plan would have conserved or controlled millions of acre-feet of the 1943 flood flows for the use of navigation, irrigation, power, and other purposes. As an example of the potentialities of the plan, the Fort Peck Reservoir controlled the entire flow of the Upper Missouri River during 1943—about 9,500,000 acre-ft—and by releases for navigation, made possible the safe passage of many military craft down the Missouri and Mississippi. At the end of 1943 there still remained in the Fort Peck Reservoir 9,600,000 acre-ft for future use.

This comprehensive plan for levees and multiple-purpose reservoirs would provide not only complete protection for the Missouri Valley from Sioux City to the mouth, against all floods of record, but also would effect important reductions in flood stages on the Mississippi River. In addition, the conservation and control of flood flows in the Missouri Basin could make valuable contributions to the navigation flows of the Mississippi River below the mouth of the Missouri.

TABLE III. PROPOSED RESERVOIRS, REPUBLICAN RIVER BASIN

PROJECT	STREAM	LOCATION, NEAR	HEIGHT ABOVE STREAM BED, FT	APPROX. GROSS STORAGE CAPACITY, ACRE-FT	APPROX. TOTAL CONSTRUCTION COST
Medicine Creek (14)	Medicine Creek	Cambridge, Nebr.	85	57,900	$ 2,400,000
Red Willow (16)	Red Willow Creek	McCook, Nebr.	87	46,800	2,100,000
Enders (17)	Frenchman Creek	Enders, Nebr.	117	93,200	6,700,000
Beecher Island (18)	Arikaree River	Idalia, Colo.	120	72,200	6,600,000
Hale (15)	South Fork, Republican River	Idalia, Colo.	90	96,400	7,200,000
Totals				366,500	$25,000,000

High-Level Bridge at Foster's Ferry, Ala.

New Concrete and Steel Structure Replaces Swing Span Over the Warrior River

By William N. Woodbury, Donald A. du Plantier, Members Am. Soc. C.E.
and Edward C. Jacob

Respectively Assistant Chief Engineer, Virginia Bridge Company; Consulting Engineer; and Erection Engineer, Virginia Bridge Company, Birmingham, Ala.

Choice of long-span continuous girders for the Foster's Ferry Bridge offered several favorable features. In addition to pleasing appearance, fabrication and erection costs could be kept down and the number of tall piers required could be reduced. To meet channel clearance requirements, and at the same time save on amount of approach fill, four rows of relatively shallow girders were used. Planning, design, and erection of this $761,000 structure are all discussed in this paper.

Eight miles south of Tuscaloosa, Ala., north-south Highway US-11 crosses the Black Warrior River at Foster's Ferry. Since 1899 the crossing has been made by means of a steel truss bridge with a center swing span. Designed for traffic conditions of the late nineties, with all field connections bolted, this bridge gave service for over forty years. High-water conditions on the Warrior are severe. One of the worst floods occurred in 1900, and the then new steel bridge was finally accepted when it was found that the crest did not reach the floor system, although it came within arm's length of it.

By the early twenties there was some apprehension as to the adequacy and safety of the span. In 1923 field bolts were replaced with rivets and the floor system strengthened. Later, under the supervision of the Alabama State Highway Department, approaches were renewed and other repairs and replacements made. Posted signs limited the bridge to loads under 8 tons but it is known that as late as 1941 this old bridge carried a gross load of 28 tons. Watchmen were stationed at both ends to control the traffic and prevent the passing of loaded trucks.

The decision to replace the bridge with a high-level structure developed in 1940, and complete plans were prepared under the supervision of J. P. Trotter, M. Am. Soc. C.E., then Bridge Engineer of the Alabama State Highway Department, assisted by R. L. Stucky on the piers, and Donald A. du Plantier, M. Am. Soc. C.E., on the steel.

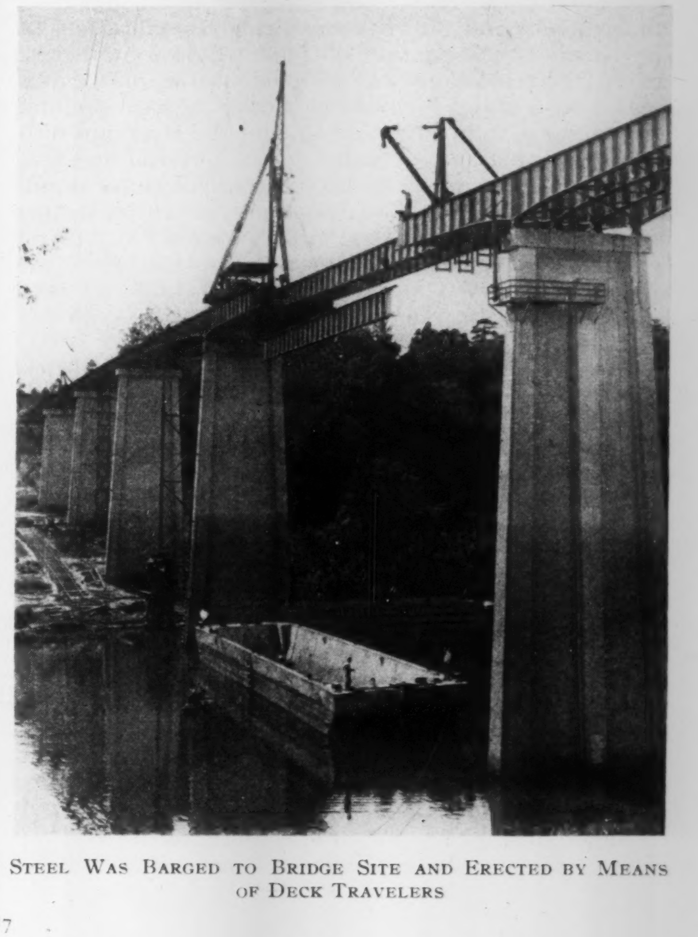
DESIGN FEATURES OF THE CROSSING

The decision to replace the old bridge was accompanied by the determination to eliminate certain dangers and inconveniences inherent in the old site. The two guiding principles adopted were to have straight approaches and to eliminate conflict between highway and river traffic by using a high overpass. The land to the north of the river is flat and somewhat below high water, hence subject to occasional inundation, whereas the south bank is a high bluff about 80 ft above flood water

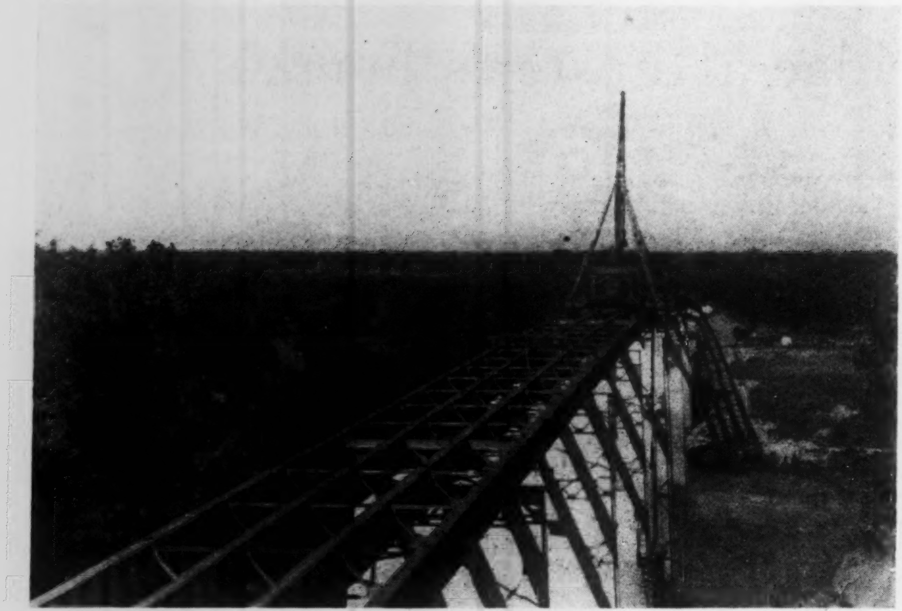
The new bridge site was located some 800 ft upstream from the old crossing, and the adjacent highway was relocated on a 2.5% grade for the south approach and a 5% grade for the north approach, curving very slightly to tie in with the existing highway. The bridge proper is on a tangent 1,330 ft long between abutments, the central portion being on an 800-ft vertical curve to make the transition between the two approach grades. The accomplishment of this profile necessitated a 20-ft cut in the south bluff and a 27-ft fill at the beginning of the north approach.

Requirements of the War Department regarding channel clearance were fixed at 200 ft in width by 52 ft in height above ordinary high water. This made the bridge soffit 91 ft above low water because of the high flood stage of this river. Underlying the alluvial top soil is a sound stratum of marl which forms the river bed. The major piers were designed to rest on this stratum to inhibit settlement and were set into it to prevent lateral displacement. As a result these piers are rather tall, some of them approximately 124 ft from base to cap. Each consists of two tapered shafts braced by a web wall and surmounted by a bearing cap to support the bridge shoes.

These web walls were discontinued below ground in order to reduce excavation and minimize the effect of any unequal earth pressure on the piers. This was particularly important on the south side, where the rapidly rising top-soil layer, including the bluff, was of an unstable nature, with a tendency to slide. This surface layer on the north side rises more gradually and is inherently stable. Here the minor approach piers were



Steel Was Barged to Bridge Site and Erected by Means of Deck Travelers



FOUR ROWS OF GIRDERS WERE SWAY BRACED AT 17.5-FT INTERVALS WHILE CONCRETE DECK BRACED THE UPPER FLANGES

carried several feet below grade, to rest on steel H-pile clusters driven to bear on the underlying rock stratum with a minimum bearing capacity of 30 tons per pile. These shorter approach piers, varying in exposed height from 25 to 45 feet, are of the open-bent type. All piers are of reinforced concrete.

DECK-GIRDER SPANS USED

Since this was a federal-aid project, it was designed to meet jointly the requirements of the U.S. Bureau of Public Roads and the Highway Bridge Specifications of the American Association of State Highway Officials. An H-20 live loading was adopted as the bridge was located on a major highway network. Several preliminary designs were investigated and the structure ultimately adopted as best suited to the physical and economic conditions was a deck type consisting of a standard concrete roadway, 24 ft wide between curbs, resting on four parallel rows of steel girders spaced 7 ft 3 in. on centers. No regular walkways were provided since the adjacent territory is sparsely populated, but the curbs were made 18 in. wide to accommodate the occasional pedestrian.

This arrangement has several favorable features. It presents a pleasing appearance; the low handrails and the absence of overhead framing give the passing motorist a feeling of space and a clear view of the surrounding terrain; the protecting concrete roadway assures low maintenance costs on the steel below. Girder construction permitted the maximum use of labor-saving machinery in the shop fabrication of fairly long units, and a minimum of expensive field-erection labor; and the use of four rows of relatively shallow, long-span continuous girders reduced the number of tall piers and met the channel clearance requirements with the least amount of approach fill.

The girders were braced laterally in the plane of the lower flanges, the concrete slab being relied upon to brace the upper flanges, and transverse sway-bracing was supplied at intervals of approximately 17.5 ft. The inner and outer rows of girders were made identical, the inner girders being raised to conform to the roadway crown. Each row is composed of four distinct units—a channel unit flanked by twin approach units on the north, and a single approach unit on the south.

The twin north approach units are continuous girders, each composed of three 86-ft spans of 48.5-in. constant depth (back to back of angles), with $^{3}/_{8}$-in. web plates, 6 by 4 by $^{5}/_{8}$-in. flange angles, and 14-in. cover plates added in one or two layers as needed. Each unit has four field splices placed in zones near moment inflection points where no cover plates are required. The first unit is straight throughout, since it parallels the 5% roadway grade, but the second unit had a slight segmental break in alinement at the fourth field splice to allow for the beginning of the 800-ft vertical curve of the roadway profile.

The south approach unit is a girder of three 105-ft spans, also 48.5 in. deep, with $^{3}/_{8}$-in. web plates, 6 by 6 by $^{5}/_{8}$-in. flange angles, and 14-in. cover plates of various thicknesses in one, two, or three layers as are needed.

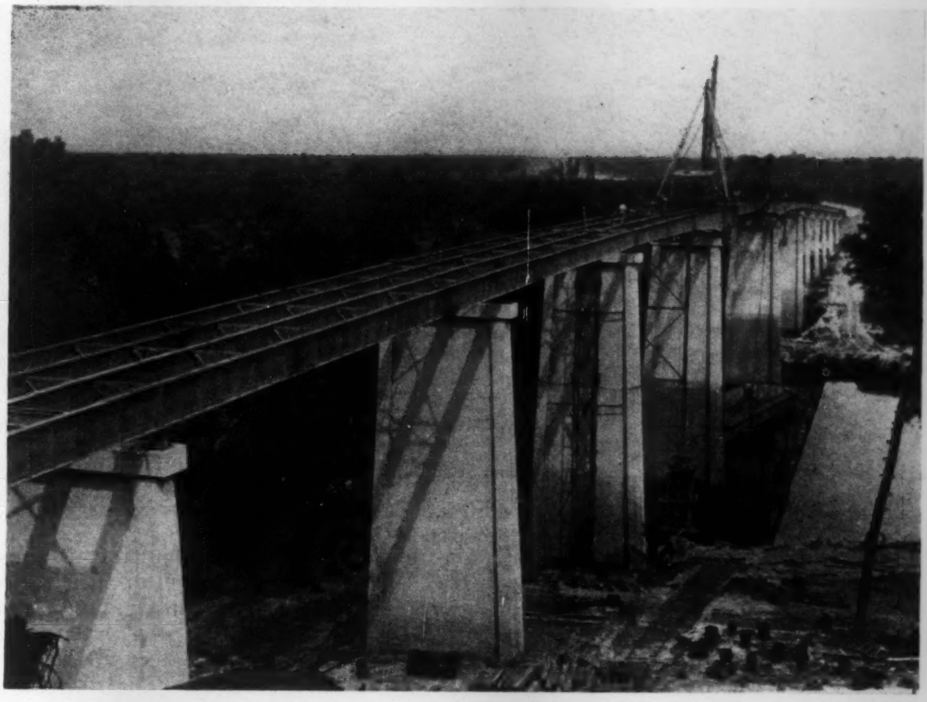
As originally designed, it was continuous over three spans; but unsatisfactory subsoil conditions under the south abutment, uncovered at the time of its construction, indicated the likelihood of future settlement. This abutment had to be placed fairly near the edge of the bluff on the south bank, in a cut high above the underlying rock stratum, which was too deep at this point to receive the steel bearing piles. This necessitated a redesign of the unit, accomplished by the substitution of a pin connection for the continuity field-splice placed in the abutment span near the inflection point some 12 ft from the inner pier. The unit thus became a two-span continuous girder with a 12-ft cover-hang, which supports a 93-ft simple-span girder running to the abutment.

Thus any settlement of the more or less floating abutment will not be detrimental to the continuous part and can be easily compensated for by jacking up the bridge seats. It might be well to emphasize here that, with the exception of this south abutment, all piers rest on the sound rock stratum previously described, either directly or indirectly through the medium of steel H-pile clusters, and the possibility of differential pier settlements is considered too remote a contingency to cause concern.

FIELD SPLICES PROVIDED

The channel unit is a three-span (140-210-140-ft) continuous girder whose depth varies from 48.5 in. over the end piers to 92.5 in. over the inner piers and 66.5 in. at the midpoint of the center span, about which the girder is symmetrical. It has a $^{7}/_{16}$-in. web plate, 8 by 8 by $^{3}/_{4}$-in. flange angles, and 18-in. cover plates, using one, two, or three layers as required. The unit was designed with four field splices, one in each outer span and two in the center span, with a maximum length of 105 ft and a weight of 25 tons. Later two additional field splices were provided in order to reduce the weight of the pieces to be handled with a single erection rig. The flange angles were made continuous between field splices and all cover plates were dropped off, since splices were designed to lie in zones of inflection points. There are eight shop splices in the webs, made necessary by the available lengths of the deeper plates.

As this channel girder unit is entirely under that part of the roadway having the 800-ft vertical curve, it would have been desirable to curve the top flange to follow the grade. However, a compromise was adopted to simplify fabrication details by placing the top flange on the slab-soffit grade at the ends and at all field splices, making the flange straight between these points and adding a slight amount of concrete immediately over the flange to achieve full bearing throughout. In order to accomplish the change in depth smoothly, yet economically, the lower flange was placed on a parabolic curve at each splice point (both shop and field) but made straight between these points, except in the region close to the center piers, where the entire flange follows the curve, with a slight reverse transition curve immediately adjacent to 16 in. of flat section over the bearing shoe. It was believed that savings in fabrication costs would justify this use of a segmental lower flange and that the departure from a true curve would not be noticeable since that part of the parabola has only a slight curvature.



Major Piers Were Braced with Web Walls, Which Were Discontinued Below Ground Level

DECK BRACES CHANNEL PIERS

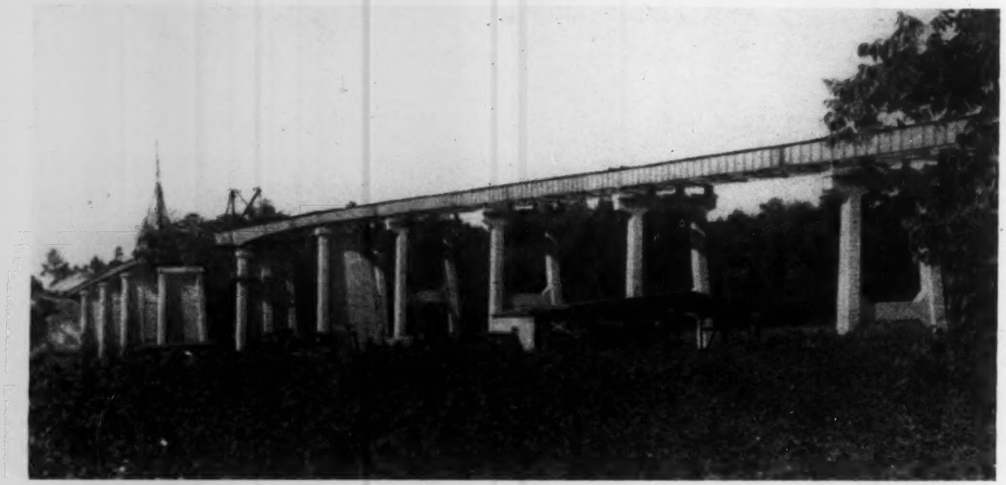
Rocker bearings were used on all end piers of each unit and fixed bearings on the inner piers. This tying together of the inner piers was believed desirable because of their unusual height. Calculations indicated that the expansion of the intervening steel due to temperature changes would not induce harmful stresses because of the relative flexibility of the tall piers. Steel bearing pins were inserted in each shoe to permit freedom of angular deformation. Each girder was cambered to allow for full dead-load deflection, and was so proportioned that the maximum live-load deflection is within the specification limit of one eight-hundredth of the span length.

The method of analysis used in computing the curves of maximum moments and shears and the camber curves was based on, and expanded from, that outlined by D. B. Steinman, M. Am. Soc. C.E., in Section 4 of *Movable and Long-Span Steel Bridges* (edited by Hool and Kinne, McGraw-Hill Book Company, 1st edition). This method of computing influence diagrams for the reactions, moments, and shears of continuous beams having varying moments of inertia, by the use of the so-called elastic weights on conjugate beams, was chosen primarily for two reasons. It permitted the use of simple and compact tabular forms in which the computations could be performed with relative ease and speed, through the use of an electric calculator, by any competent assistant without the necessity of any knowledge, on his part, of the theory involved. Also, it furnished a valuable check on the accuracy of the computations made.

Because of structural symmetry, the computed values of one outer and one inner reaction for each station position of the moving unit load, when reversed in sequence, became the simultaneous values of the two remaining corresponding reactions. The sum of each set of four simultaneous values must equal and oppose the applied unit load for static equilibrium. Consequently an independent check was needed only on the values placed initially in the tabular form. The somewhat tedious procedure of computing maximum possible moments and shears at frequent intervals along the span was necessary for two reasons: (1) such information was essential to the determination of rivet pitches and cover-plate cut-off points; and (2) the maximum values for combinations of dead load with live and impact loads involved the simultaneous use of a uniformly distributed load and a roving concentrated load, in accordance with the requirements of the specifications.

FABRICATION OF STEELWORK

Riveted construction was used throughout. Rivets were generally $^{7}/_{8}$ in. in diameter. All girder work was sub-punched and reamed, material $^{7}/_{8}$ in. thick and less being punched $^{1}/_{4}$ in. less than the normal size of the rivet, reamed when assembled, and securely bolted in position. Material thicker than $^{7}/_{8}$ in. was drilled from the solid. Girder units were completely assembled in the shop and the field splices reamed and match-marked before being taken down for shipment. On all detail drawings of girders, camber diagrams were shown with ordinates at each stiffener point. Stiffeners were spaced 2 ft 11 in. to 3 ft 6 in. on centers. The camber diagrams showed a figured elevation above or below the base line for splice points on the top chord. These splice points were connected by a straight line and the camber dimensioned at stiffener points above or below this straight line. Dimensions were given to the nearest thirty-second of an inch. Although bridge shops cannot work reasonably closer than $^{1}/_{16}$ in. in assembling steel units, the use of $^{1}/_{32}$'s saves some cumulative error. Cross frames and laterals were not reamed nor were they assembled with the girders. All steel was painted with one coat of red lead in the shop; finished surfaces were coated with white lead and tallow. It was found that paint applied on the contact surfaces of field splices caused difficulty in field riveting. There were some six-ply rivets in the splices and many of these and shorter ones could not be



APPROACH SPANS WERE CARRIED ON OPEN-BENT PIERS

driven tight until the shop coat of paint had been removed from the contact surfaces.

Estimates were prepared on erecting from both land and water. The final decision was to handle from barges. The steel was shipped to Port Birmingham, Ala., and there loaded on barges and towed 80 miles to the bridge site. The flood season of the Warrior extends over the first half of the year and was avoided for the erection period. Erection was started at the north end early in July in order to complete it before high water in the fall. A caterpillar crane was unloaded at Tuscaloosa and walked down the highway to the job. All other equipment was delivered to the site on trucks.

DELIVERY AND ERECTION OF STEEL WORK

All steel, approximately 1,000 tons, was delivered by barge in four different lots—two for the north side and two for the south. A 20-ton stiff-leg derrick was erected on the north bank to transfer materials from the barges to a push-car track for delivery to the crane and traveler. Three auxiliary bents were provided as erection supports for the long girders. Wood piling supported a 70-ft steel bent, which was moved from one location to the next as erection proceeded. The derrick was first erected close enough to the first location of the bent to drive piles and was then moved to about 100 ft from the center of the bridge to handle materials from barges.

Steel for approach spans was erected with the caterpillar crane, which also erected a stiff-leg derrick traveler with a 60-ft boom on the bridge at the north abutment. The traveler completed erection of the north end, including a portion of the center 210-ft span, and erected a 10-ton stiff-leg derrick to handle one end of the center girder. The traveler was then moved back to the north abutment, dismantled by the crane, and hauled to the south end.

Next the 20-ton stiff-leg derrick was moved across the river by barge and erected on the south bank to unload steel there. It was not feasible to use a crane on the south side as the crane weighed 40 tons and could not be moved across any of the available bridges for a distance of many miles from the site. Consequently a guy derrick was erected to handle material. The guy derrick erected the span which was within reach while the traveler was being erected at the south abutment, and handled the other steel to within reach of the traveler, which moved ahead erecting to the center span.

The four 105-ft center girders, weighing about 25 tons each, were erected direct from the barge with the traveler and stiff-leg derrick, hitches being placed so that the derrick supported 10 tons and the traveler 15 tons, corresponding to their respective capacities. After erecting and filling in these girders, the traveler and derrick were removed from the bridge.

Jacking brackets were bolted to the tops of the girders at end piers of the channel unit to adjust the openings for the center girders. This opening was made $^{3}/_{4}$ in. wide, and all four girders were erected and bolted at one end only. The other end was carried on splice plates and splice angles. When all four girders were in place, the opening was closed by the jacks until drift pins could be started in the free end of the center girder. No difficulty was encountered in making all the holes fair.

It was thought that some vertical adjustment at the end piers might be necessary to offset the deflection at splice points but this was found unnecessary.

The inside girders are $1^{5}/_{16}$ in. higher than the outside ones. After the river span was erected to the point of connection with the center girders, and the traveler removed, levels were taken. The two inside girders and the west outside girder were found to be about $1^{1}/_{2}$ in. above the calculated unloaded position at this point. The east girder, however, was about $2^{3}/_{4}$ in. above this position, and it was thought that some adjustment in the floor slab might be necessary to take care of such variations. However, after the span was erected and bolted and all equipment removed, elevations taken on the tops of the girders showed a maximum variation of $^{1}/_{4}$ in. from their correct relative positions, so no revisions in the floor slab were necessary. The other spans were within the same limits.

The north end of the river span was riveted complete, including cross frames and laterals, and the south end was about two-thirds riveted before the center girders were connected. The advisability of leaving the bottom laterals bolted until the span was erected was considered, but past experience in this type of construction indicated that this was unnecessary, as was found to be the case here.

In July 1940 the contract for the substructure was awarded to the Forcum James Company of Dyersburg, Tenn. The piers were completed in the summer of 1941, but the contract for the superstructure was not let until the fall of that year—to the Virginia Bridge Company, which fabricated the steel at its Birmingham, Ala., plant and erected with its own forces. Mill rolling of the plates required for the girders was delayed so that erection could not start until July 12, 1943. Erection was completed October 30, 1943. The concrete floor, awarded to the Milam Construction Company of Birmingham, was finished in March 1944.

The Alabama State Highway Department, under the direction of G. R. Swift, director, had entire charge of the project. J. W. Chambers had succeeded to the position of Bridge Engineer during the period of construction. S. J. Cumming, M. Am. Soc. C.E., was Division Engineer in charge, and Rex Sike was Project Engineer. The cost of the entire project, including the estimate on four miles of roadway approaches, was $761,000.

Facts and Figures on Construction Trends

I. Economic Factors Affecting Engineering and Construction Employment

By Elsie Eaves, Assoc. M. Am. Soc. C.E.
Manager, Business News Department, *Engineering News-Record,* New York, N.Y.

Civil engineers are the advance guard of economic progress. Their plans precede the construction of new facilities, and construction of new facilities precedes all of man's major new enterprise. As new enterprise expands or lags, falters, or shifts direction, construction men and the industry they sustain are the first to be affected. The extent and character of these economic shifts and changes and their effect on construction men are reviewed in Part I of this paper, which was presented before the Structural Division at the Annual Meeting of the Society. Part II of the paper will follow in the next issue.

As is well known, the construction industry functions only when men want to raise their standards of living and working. Only when men and women, either as individuals or cooperating in business or community groups, want new or better shelter for their activities; only when they seek to conserve, protect, and improve their land and waterways; only when they demand transportation ways and terminals giving better access to their work, their materials, and their recreation—only when they want, and will pay for, these improvements, does this industry function.

It is axiomatic that the construction industry is the first to know what new industries, or what other new human activities will come into being, for it starts and completes its work before these activities can begin to function.

The war has given us a striking illustration of this fact. For example, factories had to be built before guns, planes, and tanks could be produced. The engineer's plans and specifications naturally precede construction. The fact that construction, the heavy curve in Fig. 1, set a fast pace for the world's greatest production job, the dotted curve, is effectively illustrated by comparing the index of monthly construction awards for munitions plants with munitions production in the same period. Both curves are based on index numbers, with November 1941 as 100.

INVESTMENT IN CONSTRUCTION

Americans invested 17% of their entire national income in 1927 in construction and its offspring, maintenance—only 10% in 1933 (Fig. 2). In 1942, with our national effort concentrated on war, 14.5% of the national income went into construction. That put us over the war construction hump so that in 1943, while we spent as much money on construction and maintenance as in 1938, it represented only 6.3% of our greater 1943 national income, compared with 14.2% of our 1938 income spent for this purpose.

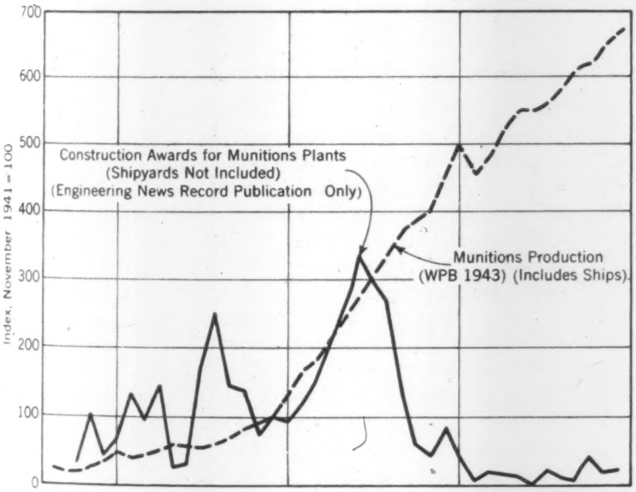
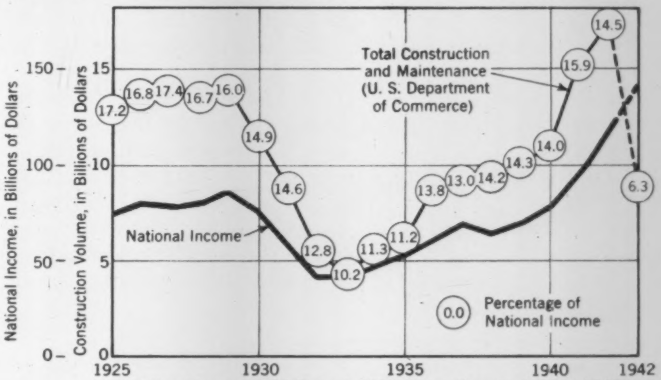


Fig. 1 Index of Awards for Construction of Munitions Plants, and for Production of Munitions

When 17% of the national income was invested in construction and maintenance, private investment predominated, even on heavy engineering construction. This period ended in 1930, as shown in Fig. 3. This chart shows, for engineering construction only, the transition from mostly private, through predominantly state and municipal construction stimulated by federal pump-priming money, into the heavy federal construction of the war period.

FUNDS FOR POSTWAR CONSTRUCTION

Private construction depends upon savings. Cumulative corporate savings, almost 20 billion dollars in 1929, began to decline in 1930 (Fig. 4). They were still low in 1942, although they had climbed halfway out of their cumulative depression low of 12 billions in 1938. In 1939 corporate savings for the single year were 21% of net manufacturing income before taxes—in 1942, 15%.



National Income 1925 Through 1938, Simon Kuznets, 1939 to 1942 (U. S. Department of Commerce)

Fig. 2. Relationship Between National Income and Volume of Construction

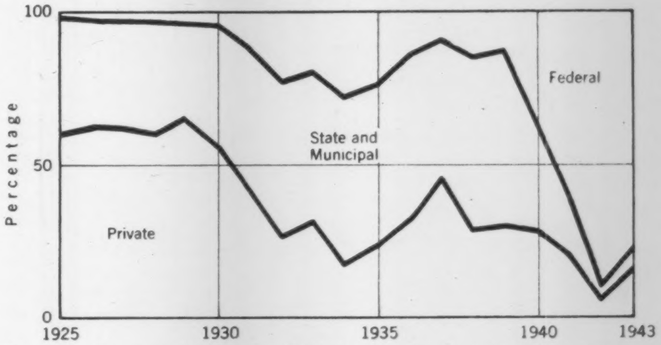


Fig. 3. Percentages of Total Construction Financed by Federal, State and Municipal, and Private Sources

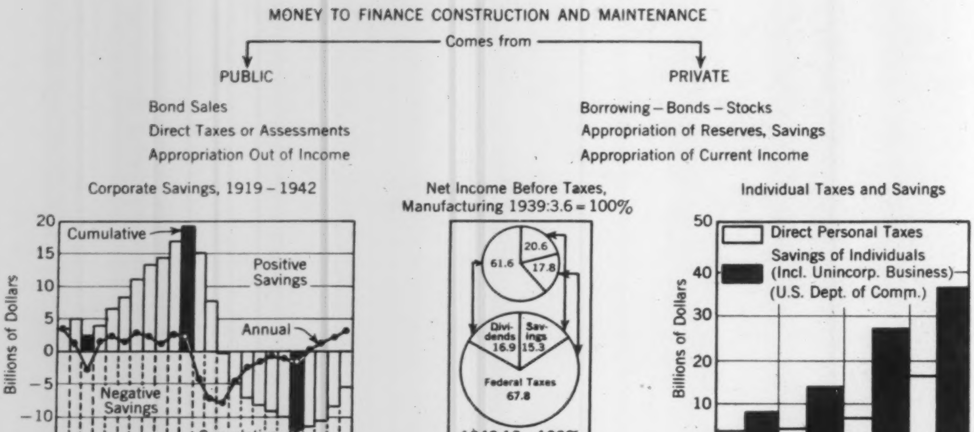


FIG. 4. ORIGIN OF CONSTRUCTION FUNDS

Dividends for the year 1939 were 62% compared with 17% in 1942, and federal income and excess profit taxes were 18% in 1939 compared with 68% in 1942. Even with the lower savings percentage in 1942, higher income provided total corporate savings of 1,860 millions compared with 760 millions in 1939. At the current ratio, corporate taxes are almost $4^1/_2$ times as great as corporate savings.

Individual savings and savings of unincorporated businesses, in spite of reductions in dividends, have shown a steady increase during the war years. They totaled 27 billion dollars in 1942. In 1940 individual savings were a little more than twice as great as direct personal taxes. In 1942 individual savings were more than four times direct personal taxes, the reverse of the corporate savings tax ratio. Note the relation between 1942 corporate savings of $1,860,000,000 and individual savings of $27,000,000,000.

Out of these funds will come the money for postwar construction. How much of it will be in the form of direct private investment through the construction industry? How much of this will be corporate and how much individual investment? How much will come through taxes and assessments to finance public construction? The future character, not only of the construction industry, but also of our whole national economy, will depend upon the answers to these three questions.

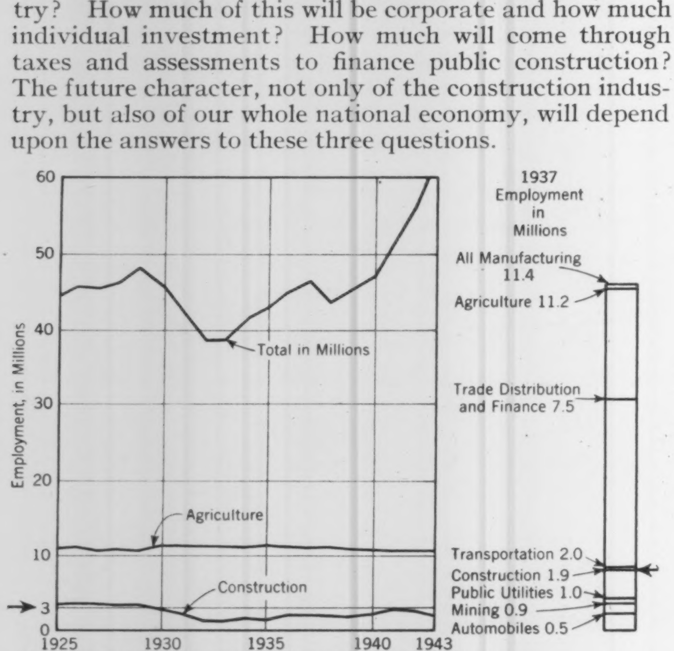


FIG. 5. CONSTRUCTION EMPLOYMENT RANGES FROM 3 TO 8% OF TOTAL EMPLOYMENT

Until the 1930's the dollar sign was used alone to measure the nation's well being, but the disastrous thirties convinced Americans that the primary source of national economic good health was the productive employment of her people. And so construction is being increasingly appraised, not alone on the basis of dollars invested, but also on that of man-hours of work created.

The great industries that employ labor, shown in Fig. 5, include agriculture, which accounted for about 25% of total employment before the war, and all manufacturing, which employed from 20 to 25%. Construction employed from 3 to 7% at the site, and required materials, equipment, and supplies that kept another 5 to 10% of the labor force employed, although this secondary or off-site construction employment is credited to other industries. Note, however, for future reference that construction employment at the site after the depression never returned to its pre-depression highs, although the total dollar value of construction in 1941 and 1942 exceeded its pre-depression highs.

The long-range employment curves show fairly clearly that construction is hardly enough tail to wag the whole employment dog. But note in how much greater ratio the construction employment curve dropped off in 1932 and 1933 than the total employment curve. Moreover, for every man that dropped off this construction curve, one or two dropped off the manufacturing, mining, and forestry curves who would otherwise have produced materials for the construction-site worker to use. In contrast observe how steady and uniform agricultural employment is. If employment in the field of transportation and other services and in the non-durable goods industries were plotted, similar minor variations would be found.

Thus, since construction employment declines fastest and farthest in a depression period, any plans for stabilizing all employment can soundly begin by stabilizing construction employment, both for its primary and for its secondary effect on employment as a whole.

KINDS OF CONSTRUCTION JOBS CHANGE RADICALLY

The foregoing kinds of curves, both of dollar volume and of men employed, show by their extreme ups and downs that the men who create and operate the construction industry must be flexible, adaptable, and rugged. As noted before, the economic trade winds and storms hit the construction industry first. They may blow with hurricane intensity one year and resemble something approaching a dead calm the next.

True as this is for construction as a whole, specialized classes or kinds of construction suffer even greater spreads between feast and famine. Commercial building construction, for example, in Fig. 6, the second pair of bars from the bottom, topped $1,670,000,000 in 1929, the climax of the skyscraper era, then toppled to $81,000,000 in 1934, mostly "taxpayers." The process was reversed in public buildings. In 1933 construction, mostly post offices, totaled $121,000,000. In 1942 munitions plants and public housing ran this up to $5,678,000,000. It ran right back again in 1943 to

$1,419,317,000. Bridge construction, $188,000,000 in 1936, was only $26,000,000 in 1943.

Comparing all classes of all construction (Fig. 7), as estimated by the U.S. Department of Commerce, military jumped from $119,000,000 in 1939 to $5,000,000,000 in 1942, nonresidential building from $1,900,000,000 to $4,900,000,000, while residential building remained practically the same at $2,900,000,000. Work relief dropped from $1,000,000,000 to $291,000,000.

One of the most difficult things for laymen to understand about civil engineers and contractors is how they can move around from one class of work to another, from bridges to buildings to airports to shipbuilding and back. To the standard explanation that the basic engineering principles are the same and only their application differs, surely all construction engineers and contractors would add, in private, that part of their flexibility, adaptability, and ruggedness can be ascribed to economic necessity.

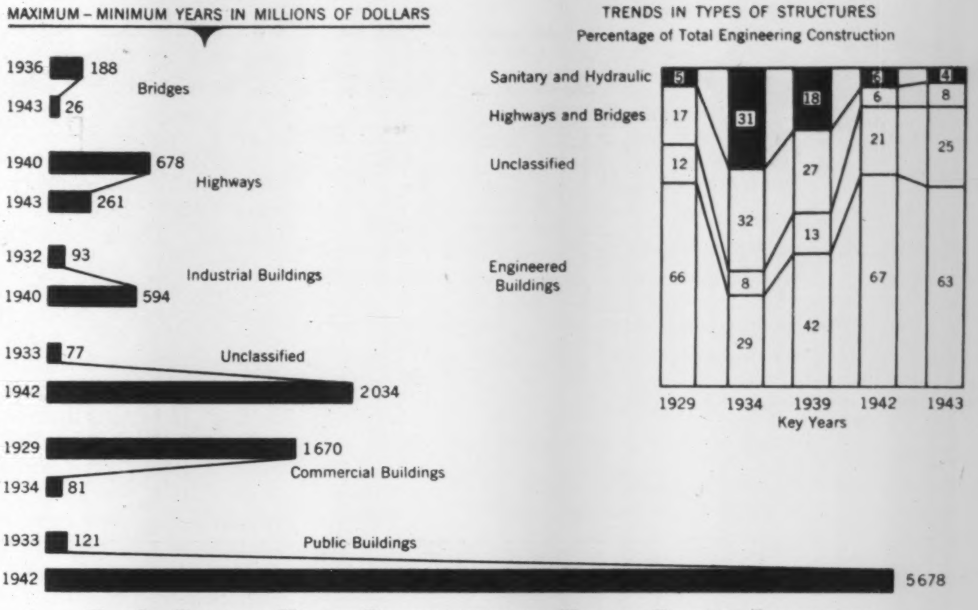


Fig. 6. Relative Yearly Expenditures for Various Types of Structures

SHIFT OF ACTIVITY FROM MIDDLE ATLANTIC STATES

What is true of shifts in volume and types of construction is true also of the location of the structures built by the construction industry. From Fig. 8 it can be seen that there has been a movement of new engineering construction away from the Middle Atlantic states. From 42% of the United States total in 1929, activity in this area declined to 13% in 1942. The South climbed from 6% in 1929 to 21% in 1942.

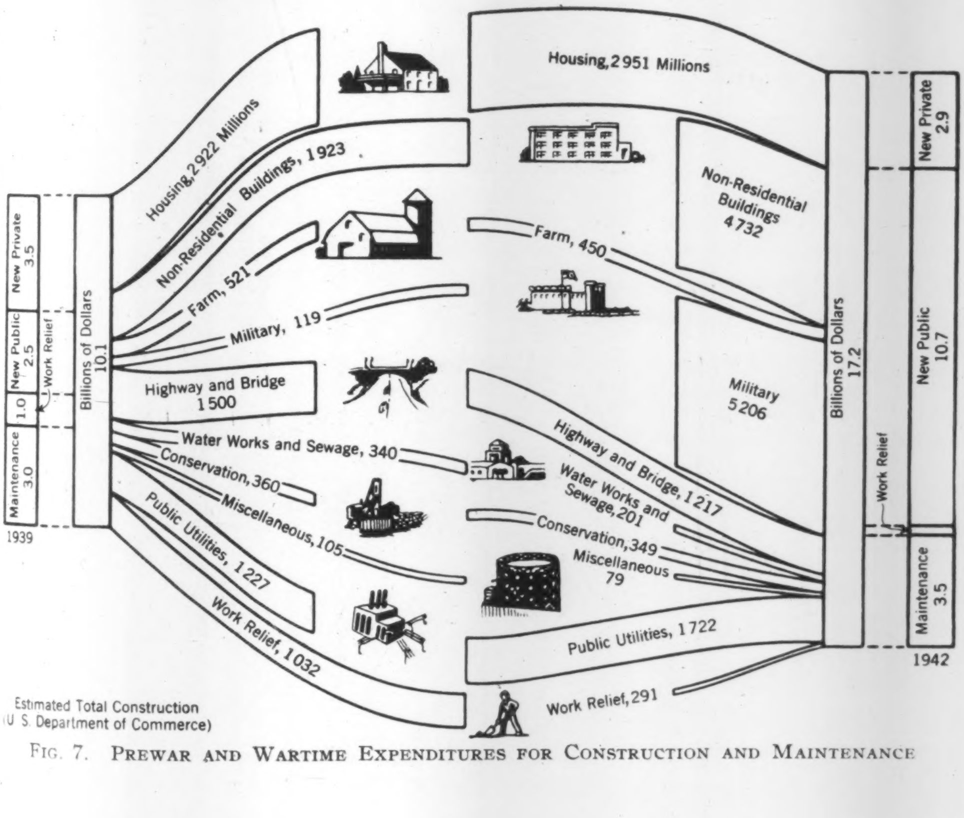
Both these shifts have been great enough and sustained enough to change the geographical distribution of engineers. Two large groups of engineers and contractors are available for use in studying this movement, both selected on the basis of their technical reading habits. In 1929, for example, 37% of the subscribers to *Engineering News-Record* worked in or out of the Middle Atlantic states; 33% in 1942. In 1934, 35% of the men who receive Civil Engineering worked in or out of the Middle Atlantic states; 30.5% in 1942.

The South had 10% of the *Engineering News-Record* engineers and contractors in 1934; 14% in 1942. It had 9% of Civil Engineering engineers and contractors in 1934; 14.5% in 1942.

The four years selected to measure these extremes in changing conditions for the construction industry are: 1929, the peak of the skyscraper era; 1934, the bottom of the depression for construction men; 1939, the last purely prewar year; and 1942, the year when war construction reached its climax and established a new, all-time high in construction volume.

TRENDS IN EMPLOYMENT OF ENGINEERS

These years saw also changes in the sources of construction employment, which can be illustrated by an analysis of engineering employment. This information exists for the same two large groups previously analyzed geographically (Fig. 9). Note, in classifications 1 and 2, that consulting engineers and contractors declined in the WPA years either in number or size of organizations or both. According to the *Engineering News-Record* group


Housing, 2951 Millions
Housing, 2922 Millions
Non-Residential Buildings, 1923
Farm, 521
Military, 119
Highway and Bridge 1500
Water Works and Sewage, 340
Conservation, 360
Miscellaneous, 105
Public Utilities, 1227
Work Relief, 1032
New Private 3.5
New Public 2.5
1.0
Work Relief
Maintenance 3.0
1939
Billions of Dollars 10.1
Non-Residential Buildings 4732
Farm, 450
Military 5206
Highway and Bridge, 1217
Water Works and Sewage, 201
Conservation, 349
Miscellaneous 79
Public Utilities, 1722
Work Relief, 291
Billions of Dollars 17.2
New Private 2.9
New Public 10.7
Work Relief
Maintenance 3.5
1942

Estimated Total Construction
(U. S. Department of Commerce)

Fig. 7. Prewar and Wartime Expenditures for Construction and Maintenance

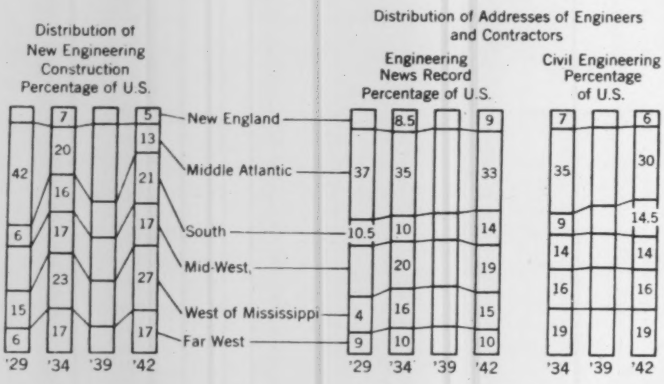


FIG. 8. GEOGRAPHICAL SHIFTS IN VOLUME OF CONSTRUCTION AND DISTRIBUTION OF CIVIL ENGINEERS

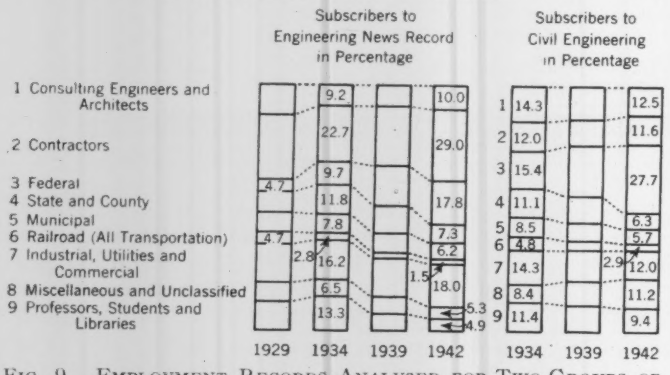


FIG. 9. EMPLOYMENT RECORDS ANALYZED FOR TWO GROUPS OF ENGINEERING READERS

analysis, they had come back by 1942 to contribute largely to construction's brilliant war record.

These percentages measure the relative distribution of active engineers and contractors. They do not reflect the decrease or increase in the total number of active engineers and contractors. The most marked change in distribution, of course, is in engineers employed on federal government staff jobs. This ranges from 9.7% in 1934 to 17.8% in 1942 for the *Engineering News-Record* group; and from 15.4% in 1934 to 27.7% in 1942 for the CIVIL ENGINEERING group.

So far the trends in type of employment of staff engineers in both groups are very much alike. In industrial, commercial, and utility employment of engineers, however, the first group shows a gain from 16% in 1934 to 18% in 1942, while the second group shows a drop from 14% to 12%.

Going back to Fig. 7, which shows trends in origin of engineering construction volume, it will be seen that the trends in engineering employment are related to the trends in new construction even though many staff engineers are engaged on maintenance and operating jobs not reflected in the charts.

So far this discussion has dealt with the conditions to which civil engineers and their confrères, architects and contractors, must adapt themselves—conditions over which they have little or no control except in their capacity as citizens whose voices help to mold general public and business policies.

SEASONAL EMPLOYMENT PROBLEM

Civil engineers are faced also with economic conditions within the construction industry and peculiar to it, over which they can and do exercise some measure of control. These problems, which offer a real challenge to engineering skill and ingenuity in the future, are the factors influencing costs on construction—high construction wage rates, seasonal and cyclical unemployment, loss of time due to weather conditions, non-repetitive operations, less mechanization than in other industries. Briefed here, these will be discussed more fully in Part II of this discussion.

Before the war skilled construction workers were paid almost twice as much per hour as factory skilled and semi-skilled workers, as shown in Fig. 10. Unskilled construction workers were paid more than unskilled factory workers by about 16%.

High construction wage rates are always defended or justified by the fact that the work is seasonal in character. Drives for more winter construction, to correct this condition, have had a marked effect in evening up summer and winter employment, but still, as recently as 1939, the average employment of construction workers by all types of contractors ranged from −26% in January to +17% in August. Employment by highway contractors ranged from −44% in February to +35% in August. Obviously here is an overall economic loss that is a challenge to the construction industry.

The heavy blow construction employment takes in a depression has already been discussed. Figure 10 shows how much worse it was, than even its nearest contender for lowest place, durable goods employment. From 1929 to 1933, when employment as a whole dropped less than 20%, construction employment dropped 60%. Correction of this serious ailment of the construction industry should not be left entirely to the economists. Possibly part of the cure can be affected internally by clear thinking, by new technical methods that increase efficiency, and by new public relations that will help construction give ever greater value for the construction dollars invested through them.

[In Part II, to follow in the next issue, Miss Eaves will discuss the methods civil engineers and contractors have used to hold down construction costs and increase construction values, together with the opportunities and challenge they face in the early future.]

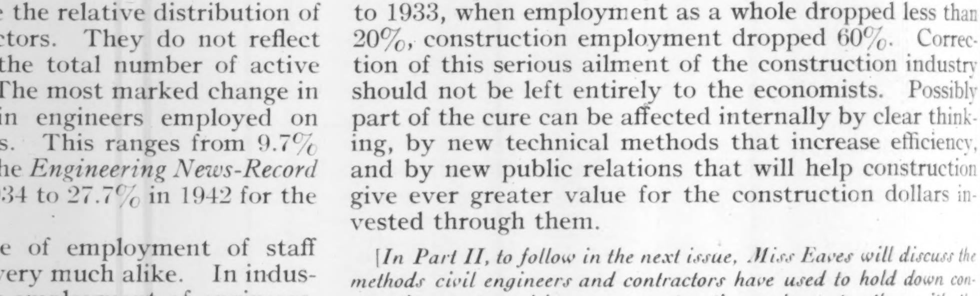


FIG. 10. WAGES AND PERIODS OF EMPLOYMENT OF CONSTRUCTION WORKERS

Development of River Measurement Equipment

By John C. Hoyt, M. Am. Soc. C.E.

Hydraulic Engineer, U.S. Geological Survey (Retired), Washington, D.C.

During a period of time well within a man's life span, instruments and equipment which have made accurate stream gaging possible have been developed. In the last half century the industrial growth of our nation has demanded increasingly dependable estimates of water resources. To meet this demand, the Water Resources Branch of the U.S. Geological Survey has enlarged its activities until today it operates more than 4,300 gaging stations. In this article Mr. Hoyt briefs the history of the river measurement equipment used by the U.S.G.S.

THE use of water, the purposes of its use, and its significance in the national economy have increased greatly in the last half century with the growth of cities, the development of irrigation, the increase in industry, and the resulting demand for water for agricultural, municipal, and industrial uses, and for the generation of electric energy. Concern has been intensified by recurring destructive floods and associated efforts to prevent or control them. With this growing interest and demand has come the necessity for more and better records; therefore more funds have necessarily been made available for obtaining such records and for developing the required instruments and equipment.

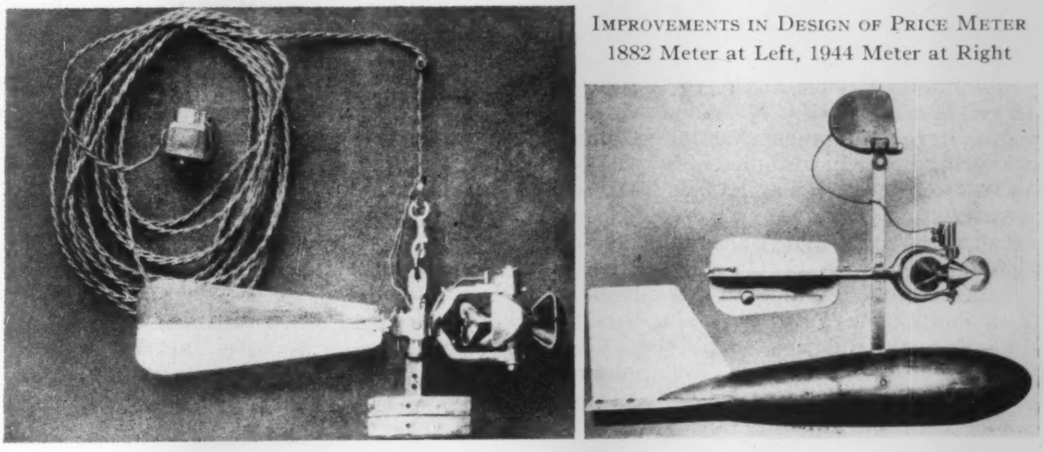
Stream-gaging by the U.S. Geological Survey began in the arid and semi-arid West in connection with the irrigation survey authorized by Congress in 1888 and 1889. Specific appropriations for stream gaging, which began in 1895, when $12,500 was appropriated, have been made annually since that time, generally in amounts that were quite inadequate, especially during the earlier years. Cooperation with states and municipalities, which had actually been in effect in small amounts since 1895, was formally recognized by Congress in 1929, when it was placed on a stable basis by the authorization of 50–50 participation. Since that action was taken, available funds have increased greatly, and during the past several years have aggregated more than $3,000,000 annually, made up of three nearly equal parts: (*a*) direct federal appropriation; (*b*) matching funds furnished by all states, the Territory of Hawaii, and many municipalities; and (*c*) funds transferred by other federal agencies to pay the costs of specific studies requested by them. The number of stream-gaging stations has increased to more than 4,300, operated through more than seventy field offices.

In the United States, attention was first given to the measurement of the flow of water in open channels between 1840 and 1850 in work on the Mississippi River and its tributaries. In 1840 Humphreys and Abbott started their extensive investigations on that river, and about the same year Charles Ellet used gage heights and a rating curve based on discharge measurements to determine the rate of discharge of the Ohio River at Wheeling, W.Va. In 1855 James B. Francis (later Hon. M. Am. Soc. C.E.) published the results of his investigations at Lowell, Mass., and developed his formula for flow over weirs. In 1870 Gen. T. G. Ellis, M. Am. Soc. C.E., in his work on the Connecticut River, added many valuable data. It was not until 1888, however, when the U.S. Geological Survey began to collect data in regard to the flow of streams and the water supply of the country at large, that the general applicability of hydraulic laws as related to stream flow was investigated. Before that time little had been done on the development of methods, instruments, and equipment for determining the regimen or flow distribution of streams.

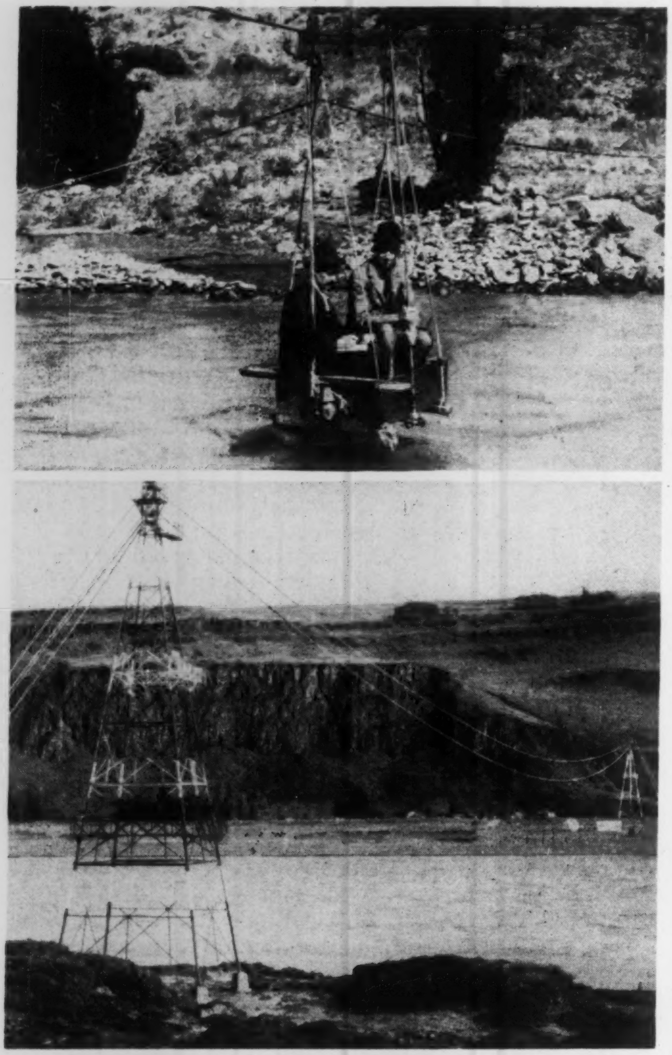
One of the early difficulties in this work was transportation. River-measurement engineers who now visit gaging stations in heated automobiles equipped with radios do not appreciate the difficulties of travel before the introduction of the automobile, when trips were made by train, by horse and wagon, on horseback and, in some localities, on foot, and the equipment had to be carried. Even when adequate transportation was available, equipment was always a problem and a minimum amount was taken. Besides his necessary personal belongings, the engineer had to carry the current meter, meter box, a level and a leveling rod, a wading rod, a mason's bag containing meter cable, weights and necessary small tools, often a camera, and during winter months, an ice chisel.

The introduction of the automobile solved the transportation problem. Heavier and more efficient weights were developed, aluminum booms and reels for placing the meter were devised, the water-stage recorder and the wire-weight gage perfected, control sections built, cableways made safer, and many improvements effected in auxiliary equipment. In all these developments the automobile was a factor—direct or indirect. Privately owned autos were used to a limited extent before 1913. Following detailed reports of their economy, the purchase of automobiles was officially recognized after that date, and two cars were bought with federal funds for use in Utah and Nevada.

A season's trial demonstrated that they were so economical, both in the saving of time and in the cost of operation, in comparison with the cost by other means of travel, that they were introduced in all sections of the



Improvements in Design of Price Meter
1882 Meter at Left, 1944 Meter at Right



CABLE STATION OF 1890 ABOVE, AND STATION USED IN 1937 BELOW

country and were soon considered an essential part of the equipment for river measurement work. Their use materially reduced transportation costs, and it was possible to carry all needed equipment for maintaining the stations in good condition.

Active development of field equipment for river-measurement work started at the time the U. S. Geological Survey undertook this work on a nation-wide basis. The equipment available today is largely the result of the efforts of Survey engineers over a period of many years. Among these men special mention should be made of E. G. Paul, who was one of the pioneers and did much in this field; W. G. Steward, who also gave valuable assistance in the early days; The late Lasley Lee, M. Am. Soc. C.E., under whose direction much of the later development was made, and who maintained a clearing house in his office where the ideas of various field men were tested; and C. H. Au, whose work on the water-stage recorder, wire-weight gage, discharge integrator, booms and reels, and other accessory equipment was outstanding.

While the development of adequate field equipment was a major factor in the advancement of river-measurement work, mention should be made of the improvements in office methods and appliances. Among these the discharge integrator was of special importance. The idea of an instrument for converting a graphic record of daily river stage into daily discharge was considered as early as 1905. F. W. Hanna, M. Am. Soc. C.E., and others suggested such a device and the matter was considered by W. G. Steward. In 1915, E. S. Fuller built an instrument by which the mean daily gage height could be taken from a gage-height graph. This instrument was later developed by Mr. Fuller, aided by Mr. Au, to give the daily discharge directly from a continuous gage-height graph, which stimulated the use of water-stage recorders. On June 30, 1943, out of over 4,300 river measurement stations maintained by the U. S. Geological Survey, over 3,900 were equipped with recorders.

The result of the studies on the effect of ice on winter flow (in 1911–1913) by W. G. Hoyt, M. Am. Soc. C.E., was the basis for the method used in computing winter flow, which has since become standard.

For river measurement the essential instrument is the current meter. In the various early meters the number of revolutions of the meter wheel was indicated by a mechanical device, and it was necessary to take the meter out of the water for each reading. In 1860, D. Farrand Henry, M. Am. Soc. C.E., of the U. S. Lake Survey, invented an electrical device which indicated the number of revolutions of the wheel while the meter was in the water, thus eliminating the difficulties peculiar to the mechanical indicator. It was improved by the use of telephone ear-pieces operated by a small dry cell, suggested by the late Louis C. Hill, Past-President, Am. Soc. C.E., and developed by W. G. Steward.

The earliest patents for current meters were granted in 1851. Patents have been claimed on more than 50 devices (classified under "Ships Logs") for measuring the velocity of water, and many unpatented devices have been constructed. The only meters that have had general use, are the Price, Haskell, Fteley, and Ellis.

DEVELOPMENT OF PRICE METERS

In January 1882, W. G. Price, later M. Am. Soc. C.E., a civilian engineer employed by the Misssippi River Commission, was detailed to measure the Ohio River at Paducah, Ky. No adequate meter was available at that time, and his equipment consisted of an Ellis cup-type meter and a Haskell propeller-type meter. It was not possible, however, to exclude silt from the bearings of either of these meters, and the Ohio was so muddy as to seriously affect the ratings. Price requested the Commission to furnish a satisfactory meter for use under these conditions, but the only reply received was that such a meter was not available and to do the best he could.

Price conceived the idea of a meter with horizontal cups mounted on a vertical shaft with an inverted cup bearing which would entrap air and exclude water and silt. Vertical bearings were required to accomplish this result. He selected the Ellis cup-type meter as the basis for his design and made the drawings for such a meter one evening. It was completed the next day by four mechanics. This meter has been called the "large Price meter" and was patented by Mr. Price on August 25, 1885, patent number 325011. The original meter is now in the National Museum. The effectiveness of the original Price meter was shown by the fact that measurements obtained with it were more consistent than those obtained by other types, and it has served as a basis for other types of the Price meter used today.

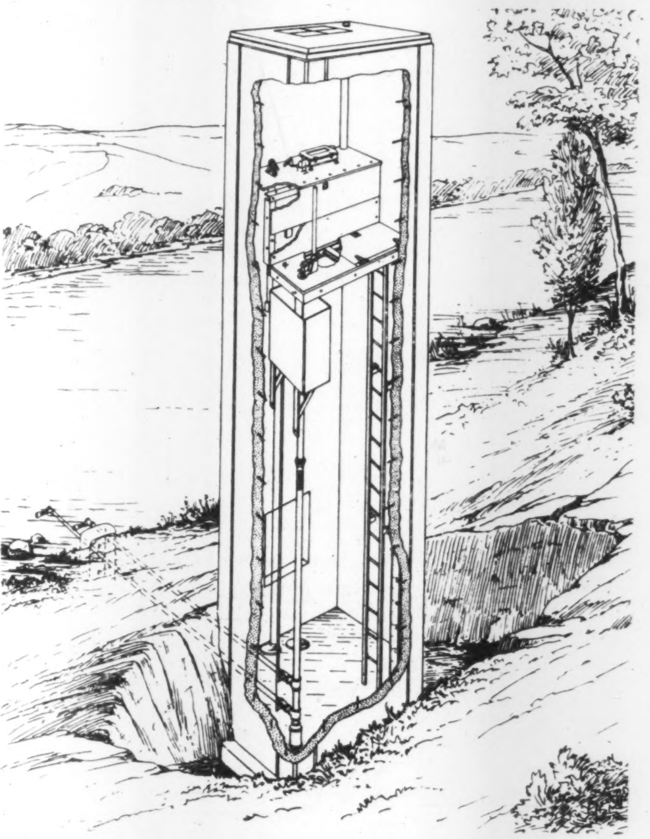
On May 18, 1897, Mr. Price obtained a patent on the "acoustic meter," patent No. 582874. It was built on the same fundamental principle as the large Price meter, but smaller cups were used and the meter was more compact. The cups were of conical shape and were

Transportation Facilities Have Progressed from the "Armstrong" Model of 1904 (Left), to the Completely Equipped Truck of 1944 (Right)

evidently suggested by the cups used in the Ellis and Colorado meters, which were similar to those used on the Robinson anemometer.

In June 1895, the Geological Survey purchased two acoustic meters, which were used by W. G. Russell in Kansas and which commended themselves for their extreme lightness and sensitivity. Both the large Price meter and the Price acoustic meter were used extensively during the next two years, but the large meter was found to be too inconvenient for general use. In 1897, F. H. Newell, M. Am. Soc. C.E., then Chief Hydrographer of the U.S. Geological Survey, asked resident hydrographers throughout the country for ideas as to improvements in equipment. As a result of the suggestions received, E. G. Paul designed a meter combining the cups of the acoustic meter with the general arrangement of the large Price meter.

This meter was known as the "small Price meter." It consisted of a vertical U-shaped yoke to support a vertical shaft, to which was attached a small horizontal frame holding the small conical cups. The lower end of the shaft was fitted with a deep inverted bearing which entrapped air and excluded water and silt from the bearings—the basic idea of the original Price meter. The upper end of the shaft and contact points were in an inverted air-tight box which also excluded water and silt. Most of the wear in the bearings which occurred in the meters of other designs was eliminated, and it has been found especially satisfactory in river-measurement work under the widely varying conditions met by the Survey.



Recent Design of a Water Stage Recorder Station

There have been no fundamental changes in the essential features of this meter: it gives practically the same results and measures velocity with the same high degree of accuracy as it did originally. There have been many changes, however, in its construction, especially in the arrangement for its suspension and the device for indicating the revolutions of the wheel. The idea of the penta-count electrical device to indicate each fifth revolution of the wheel resulted from the use of the Price acoustic meter on streams of the Nome Peninsula, Alaska, in 1906. This device was built by W. G. Steward on suggestions from John C. Hoyt, who had used the acoustic meter in Alaska. At that time sliding connections and other simplifications in its construction were made by Mr. Steward

In order to make the Price-type current meter more readily adaptable for use in very shallow water, a so-called "pygmy meter" was developed by engineers of the Survey. This is similar to the ordinary Price meter in its design, but is only two-fifths of its size, and is adapted for rod suspension only. More than 200 of these meters have been constructed, all of them by the Survey's Division of Field Equipment.

All types of Price meters described, except the pygmy, have been made by W. and L. E. Gurley, of Troy, N.Y., who also assisted in their development.

The changes in the value of water, and the improvements in instruments and equipment for its measurement, have come about as a result of normal requirements. They have been emphasized but not changed by the demands of water for war purposes, which may be well illustrated by the great number of special reports on surface water made by the U. S. Geological Survey since Pearl Harbor at the request of war agencies, war contractors, overgrown municipalities, and others.

There is no thought that the end has been reached in water investigations, or that perfection has been attained. Water will continue to be needed in ever greater quantities; yet the limits of supply have been reached in many localities, not only in the arid states of the West, but also in the humid industrial states of the East. Demands for more and better stream-flow records than are now being obtained will surely follow. The demands encompass ground water, which is also a important source of supply, and the chemical quality of both surface and ground water, especially in relation to agriculture, municipal supplies, and industrial uses.

Basic Hydraulics of Water Storage Projects

III. Spillways, Outlets, and Surge Tanks

By George R. Rich, M. Am. Soc. C.E.
Chief Design Engineer, Tennessee Valley Authority, Knoxville, Tenn.

Simplicity of design worked out in conformance with natural laws has marked the work of engineers of the TVA. In this series of articles, which began in the August issue, Mr. Rich has given the fundamentals considered in the design of multiple-use projects. In this article he discusses the selection of gates, the conditions under which surge tanks must operate, and examines several other elements of hydraulic structures.

On main-river projects, selection of the type and number of spillway gates is closely interwoven with the basic economic design of the project as a whole. (See "Waterways and Gates for Hydroelectric Plants," by George R. Rich and Ross M. Riegel, Civil Engineering for February 1941, p. 101.) For example, on the Pickwick, Guntersville, and Chickamauga (Fig. 1) projects, in which the natural site is characterized by a wide flood plain with great depth of overburden and a relatively narrow river channel in rock, it is obviously most economical to confine concrete structures to the main river bed and employ embankments on the flood plain. To accommodate the heavy flood discharges on the lower river and yet leave sufficient space for the navigation lock and power station, it is essential to use gates of the greatest practicable depth supported by reinforced concrete piers so as to secure minimum obstruction of the waterway.

The high degree of submergence during floods dictated the adoption of fixed-roller rather than tainter gates. This is because in any practical layout the anchorages, trunnions, and neighboring trussed framing of the latter type would be susceptible to fouling and damage from debris, while the fixed-roller type of gate can be completely raised above the flood and latched at deck level.

Because of the size of the reservoir and the fact that upstream forecasting is available to give several days' advance warning of floods and to guide normal water-dispatching operations, gantry cranes were adopted as a sufficiently rapid means of gate operation. The use of a sectionalized gate of two leaves per bay afforded additional economy because of the resulting reduction in gantry-crane height and capacity, and consequently in the weight of the spillway deck framing. This arrangement also afforded greatest flexibility in normal operation since it was found feasible from the hydraulic standpoint to pass normal regulatory discharges between the leaves simply by raising and dogging the upper leaf any desired amount. Upstream slots identical with the main-gate slots permit the use of one extra standard bay of gates for emergency gate service. Standard provisions are made for automatically engaging and operating the gate leaves under water.

Similar considerations dictated the use of fixed-roller gates at the Kentucky project (Fig. 2), the essential difference in natural conditions being the exceptional depth of overburden not only on the flood plain but also in the main river channel. This required an unusually deep and expensive cofferdam and further accentuated the need for a spillway having gates of the greatest practicable depth. The distinctive feature of the Kentucky spillway results from the primary function of the project as a flood-control retention reservoir and consists in the use of three, rather than two, gate leaves in each bay.

Operating reservoir level is held just below the top of the middle gate, and the upper leaves are kept normally in the storage position. They are deposited in the slots only when it is desired to retain exceptional floods on the Tennessee until similar floods on the Ohio and Mississippi have passed. An interesting mechanical detail is the substitution of torpedo-type grappling blocks and single-line lifting chains for the structural-steel latching followers and multipart wire-rope hoisting blocks adopted for the upstream projects.

On the Wilson and Wheeler projects there is no flood plain. The river channel is shallow, with a wide rock floor extending between high bluffs; consequently masonry structures with no embankment sections are

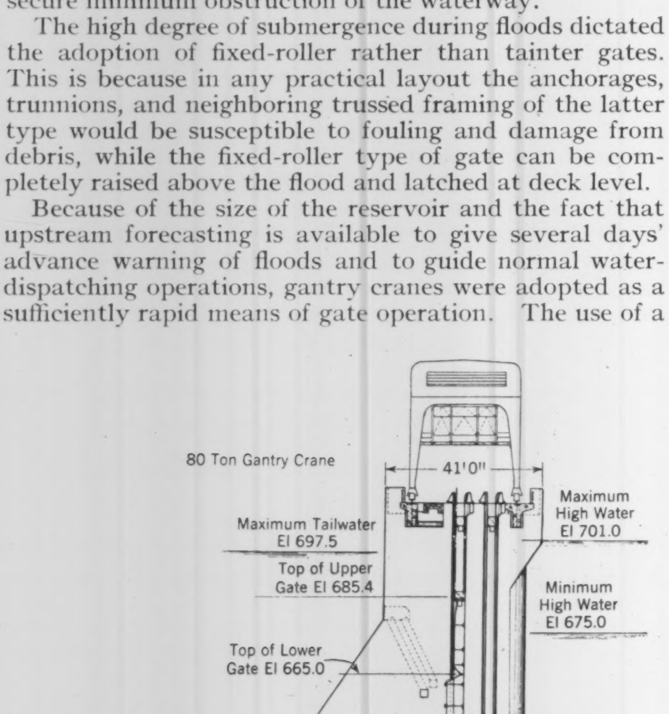

80 Ton Gantry Crane
41'0"
Maximum Tailwater El 697.5
Maximum High Water El 701.0
Top of Upper Gate El 685.4
Minimum High Water El 675.0
Top of Lower Gate El 665.0
Crest El 645.0
Top of Original Rock
Minimum Tailwater El 628.0
1
1
Base Line
El Varies
106'3"
18'9"

Fig. 1. Section Through Spillway at Chickamauga Dam

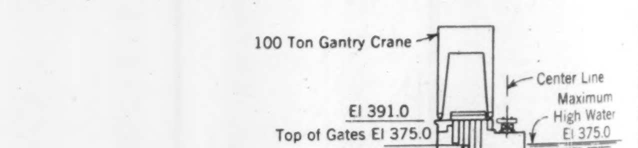
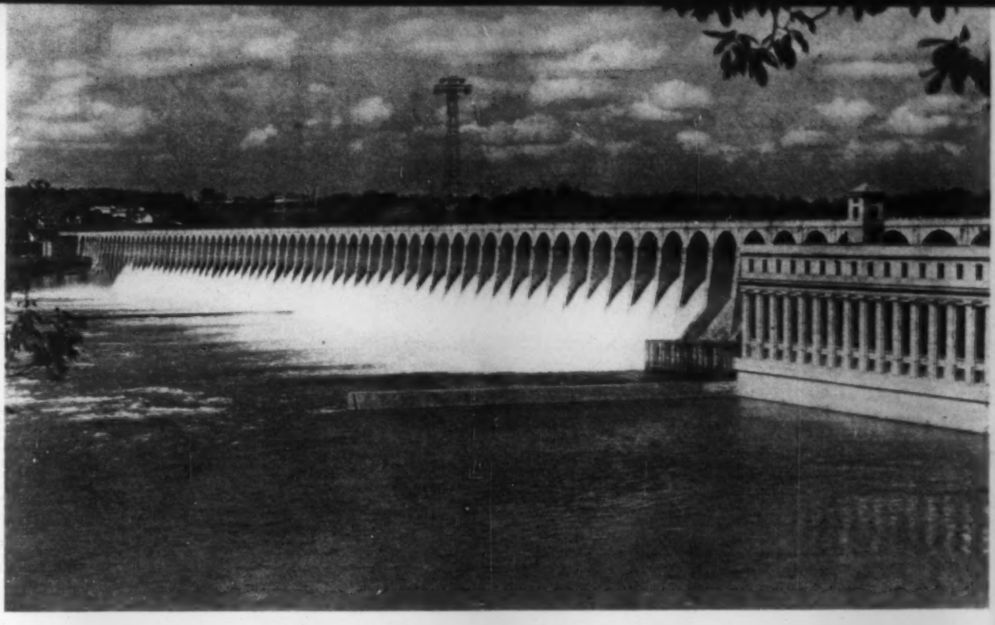

100 Ton Gantry Crane
Center Line
Maximum High Water El 375.0
El 391.0
Top of Gates El 375.0
Maximum Tailwater El 360.0
Maximum Recorded Tailwater El 348.8
Normal High Water El 359.0
Crest El 325.0
Minimum Tailwater El 302.0
30.5'
0 20 40 60
Scale in Feet
15.0'
Rock Varies
230.0'

Fig. 2. Section Through Kentucky Dam Spillway



Wilson Dam, Constructed in Restricted River Channel Without Embankment Sections

employed. To minimize erosion with the low depth of tailwater, a large battery of shallow crest gates is employed. Tainter gates are used at Wheeler, and counterweight fixed-roller gates at Wilson.

Spillways of the two upstream river projects, the Watts Bar and Fort Loudoun developments, are controlled by tainter gates. The use of such gates is feasible because the flood discharges are lower, the heads are higher, and the trunnions and framing of the gates can be kept above tailwater at all times. Emergency dewatering of gates is accomplished by means of a floating caisson sealing against the upstream faces of the piers. Operation of the gates is accomplished by low crab-type hoists and dielock chains, which can be dogged at deck level on any link for any desired degree of gate opening.

In the interest of standardization it was found possible to employ identical design and details for the fixed-roller gates and accessories at the Pickwick, Guntersville, and Chickamauga projects, and also for the tainter gates installed at Watts Bar and Fort Loudoun.

To assist in dissipating the emergency of the overflowing discharge, the standard type of flat concrete apron, with elevated terminal sill, was found to be satisfactory for all main-river developments. The action of the apron is to induce the formation of a back roller and thus dissipate the kinetic energy of the overflow in the form of heat.

MAIN-TRIBUTARY STORAGE SPILLWAYS AND OUTLETS

For the higher-head storage developments at Norris, Hiwassee, Cherokee (Fig. 3), and Douglas, radial gates were selected as the most simple, effective, and economical means of crest control. In the interest of standardization, the same tainter gates and accessory equipment—identical in every detail—were installed at Cherokee and Douglas as were employed at the Watts Bar and Fort Loudoun main-river developments.

Selection of the type of low-level sluice outlets for Cherokee and Douglas was influenced very strongly by wartime procurement conditions. The result was the adoption of simple rectangular slide gates operated by oil-pressure cylinders, for which a standard design and patterns for casting were available. However, since there appears to be no necessity for operation at partial openings, this type has proved in actual experience to be well adapted for the intended service. Possibly the most effective feature, which is now standard for all sluice installations of the Authority, is the provision of a contraction on the nozzle in the discharge end of the conduit, which insures a back pressure of not less than 40 ft on all sections of the conduit.

The Fontana project, Fig. 4, with its gravity dam having a height of 450 ft above the foundation, presented a special problem. The natural gorge is so narrow that adequate space for the power station, tailrace, and dissipating structure that would have been required for the accommodation of discharges over or through the dam, was not practically available. In addition, to avoid conflict with the high-speed wartime concreting program, requiring a peak pouring rate of 250,000 cu yd per month, it was believed advantageous to keep spillway discharge conduits entirely separate from the main dam structure. This objective was accomplished by providing twin concrete-lined discharge tunnels of 34-ft diameter in the solid rock of the left abutment. By supplementing the inclined tunnels with low-level branches, which were subsequently plugged, it was found possible to divorce all provisions for river diversion during construction from the critical problem of high-speed placement of concrete in the main dam.

Discharge to the inclined tunnels from the reservoir is controlled by means of four tainter gates located on the crest, and six rectangular sluices located in the body of a conventional ogee section. This arrangement gives a high degree of flexibility in operation for reservoir levels either above or below the ogee crest, with latitude for adjusting flow to give optimum hydraulic conditions at the entrance to the tunnels. In plan, each tainter gate is oriented to converge on the funnel transition to each tunnel. The tainter gates are operated by individual hoists with auxiliary hand operation, and the mechanisms are so connected as to give the same degree of opening for each pair of gates. The tainter gates are equipped with a special overflow crest to accommodate emergency discharge resulting from failure to open the gates.

Dissipation of the energy of discharge below the tunnel portals is accomplished by means of buckets about 75 ft long, so shaped as to deflect the water upward into the air and divert it toward the middle of the river channel. The resulting jet is both wide and long, and on the basis of laboratory tests will provide an effective means of inhibiting erosion in the river channel.

For the accommodation of exceptionally rare floods, there is an emergency spillway consisting of a fixed-crest arch dam with secondary stilling pool for dissipating the energy of overflow. The 15-ft-diameter tunnel on the right bank, provided primarily for construction railroad service, was adapted at comparatively small expense to

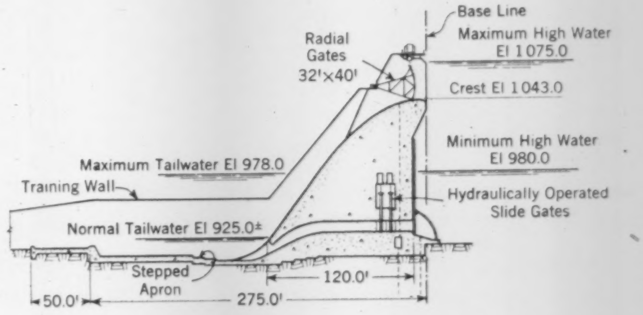

Base Line
Radial Gates 32'×40'
Maximum High Water El 1075.0
Crest El 1043.0
Minimum High Water El 980.0
Maximum Tailwater El 978.0
Training Wall
Hydraulically Operated Slide Gates
Normal Tailwater El 925.0±
Stepped Apron
120.0'
50.0'
275.0'

Fig. 3. Spillway Section at Cherokee Dam

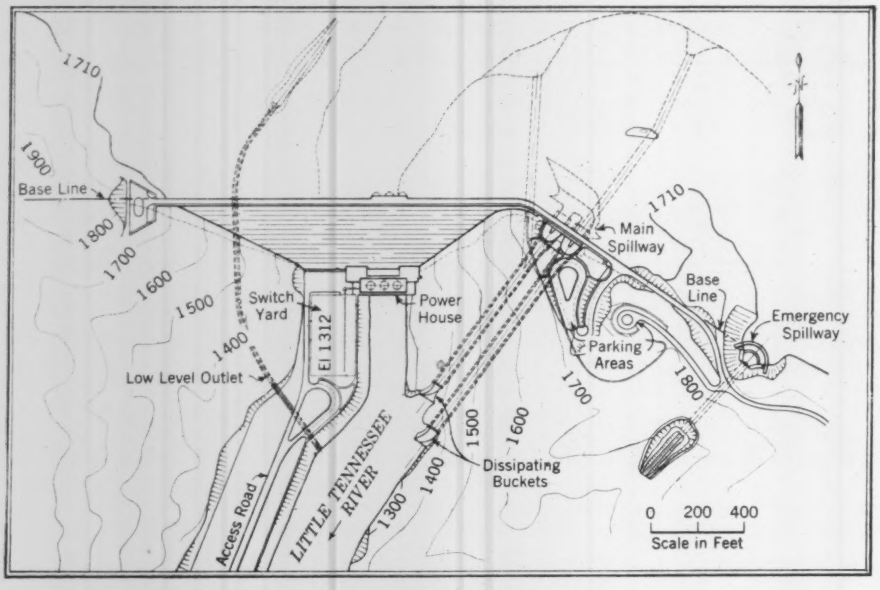

1710
1900
Base Line
1800
1700
1600
1500
Switch Yard
1400
Low Level Outlet
El 1312
Power House
Main Spillway
1710
Base Line
Emergency Spillway
Parking Areas
1700
1800
1500
1600
1400
1300
Dissipating Buckets
Access Road
LITTLE TENNESSEE RIVER
0 200 400
Scale in Feet

FIG. 4. GENERAL PLAN OF FONTANA DAM, WITH SPILLWAYS IN ABUTMENT

serve as a low-level emergency discharge outlet. A Howell-Bunger valve regulates the discharge.

It is believed that the surge tanks used at the Ocoee No. 3 and Apalachia developments will be of interest from the hydraulic standpoint because of an improved type of port construction (Fig. 5), particularly applicable where it is essential to accommodate a very large load demand. In the case of these tanks, the operating officials of the Authority stipulated that the surge-control system be capable of absorbing, in so far as practical, a 100% instantaneous load. The design provided permits absorption of this demand except at extreme minimum head, at which the instantaneous maximum demand is limited to about 80% of wheel capacity by lack of head in the so-called heel zone of the riser drop curve.

In the ordinary case, in which the tank is designed for an instantaneous rejection of 100% load and an instantaneous demand in the order of 25% load, it is readily possible to obtain a single value of port area suitable for both demand and rejection conditions, largely because of the fact that a few seconds after the initiation of rejection a large volume of water spills over the top of the riser pipe, and also because of the reduced discharge at the higher head used in calculating the rejection condition. However, it is readily seen that in designing tanks for large percentage load demand there will be a disparity between the port areas for demand and rejection, the area suitable for demand being too large for rejection.

In European installations, the standard means of obtaining the requisite compensation of port area is to install movable flap valves which close for the rejection condition and open for the demand condition. Because of the obvious undesirable features of such design, an attempt was made in the Ocoee No. 3 and Apalachia installations to attain the same objective by means of an entirely static structure. This was accomplished by designing the ports as flared bell-mouth orifices, with the flare turned upward so as to cause convergence and compression of hydraulic filaments. Thus there is a high discharge coefficient for the demand condition, but under the reverse condition discharge is sufficiently diminished to effect the required compensation. On the basis of tests at the Hydraulic Laboratory, it was found entirely feasible to obtain an orifice of this type that would have a discharge coefficient of 0.94 for the demand condition, and a corresponding discharge coefficient of about 0.71 for the rejection condition. Prototype operating tests have confirmed the accuracy of the design. Thus by entirely static means it has been found possible to accommodate conditions of exceptionally large demand without the use of moving parts. The demand and rejection curves for actual operation follow very closely the values calculated by arithmetic integration. The port design was developed in collaboration with P. F. Kruse, M. Am. Soc. C.E., who was retained as consulting engineer for surge-tank and water-hammer work.

In conclusion, if it were possible to embody in a single word the most important of all basic principles of hydraulic design, it would be insistence upon "cleanness." This term, difficult to define precisely, is nevertheless readily comprehended by all engineers. It implies ruggedness, simplicity, economy, and working to conform with, rather than to circumvent, natural laws. It is exemplified in the venturi-loop lock; the turbine setting with straight piers and without islands, splitters, or ultra-refinement in curved surfaces; in the surge tank without flap valves; in the Fontana Dam section, free from embedded parts that conflict with the main requirement of rapid concreting; in the ring-girder penstock design, free from the complication of stiffener angles and rivets. "Cleanness" is the hallmark of good practice; it is the initial and final test of any design.

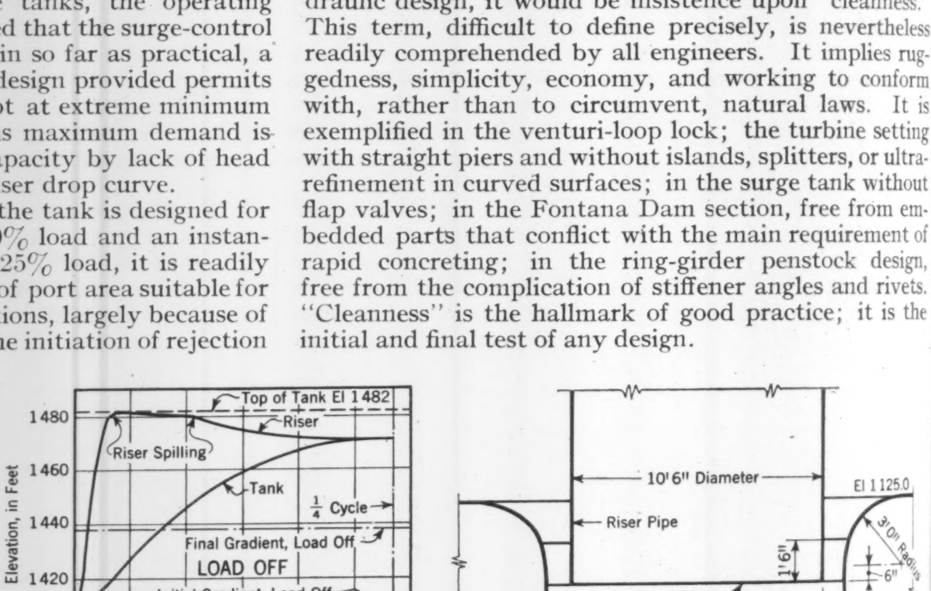

Top of Tank El 1482
Riser
Riser Spilling
Tank
1/4 Cycle
Final Gradient, Load Off
LOAD OFF
Initial Gradient, Load Off
Elevation, in Feet
1400
1420
1440
1460
1480
0
20
40
60
80
100
120
Time, in Seconds
Minimum High Water
LOAD ON
Final Gradient, Load On
Tank
1/4 Cycle
Riser
Bottom of Tank
Elevation, in Feet
1340
1360
1380
1400
1420
Time, in Seconds
10'6" Diameter
El 1 125.0
Riser Pipe
1'6"
3'0" Radius
6"
Bottom of Riser
12"
CONDUIT: L=13 100 FT, A=130 SQ FT, R=3.17
LOAD OFF: 100%
High Water El 1438
Q=1 590 Cu Ft per Sec
V2=12.23 Ft per Sec
n=0.0115
Port Coefficient=0.71
LOAD ON: 100%
High Water El 1413
Q=1 490 Cu Ft per Sec
V2=11.47 Ft per Sec
n=0.013
Port Coefficient=0.94

FIG. 5. DESIGN FOR SURGE TANK PORT AT OCOEE NO. 3 PROJECT

Engineering Aspects of Mosquito Control

I. Anti-Malaria Program of the Tennessee Valley Authority

By W. G. Stromquist, M. Am. Soc. C.E.

Principal Sanitary Engineer, Health and Safety Department, Tennessee Valley Authority, Chattanooga, Tenn.

One of the largest and most comprehensive attacks on the mosquito problem has been effectively carried on in the Tennessee Valley. The variety of methods and objectives, together with the excellent results, are described in this paper, delivered before the annual meeting of the Sanitary Engineering Division. Papers on other phases of the problem will appear subsequently.

Development of the Tennessee River system for flood control, navigation, and hydroelectric power is potentially the greatest example in this country of what has been termed "man-made malaria"—that caused by artificial breeding places for malaria-carrying mosquitoes, such as undrained borrow pits. Impounded reservoirs provide ideal breeding places for the *anopheles quadrimaculatus* mosquito, the malaria vector in the Southeast.

Since malaria is a disease of human beings transmitted by mosquitoes, part of whose life cycle is aquatic and closely associated with aquatic vegetation, several sciences are involved in its control—medicine, entomology, botany, limnology, parasitology, and engineering. The engineer's function, in addition to technical planning, is to make practical application of the knowledge developed by the other sciences in controlling the mosquito and in protecting man from the mosquito.

The immensity of this problem facing the Tennessee Valley Authority is shown by the fact that its nine main-river reservoirs shortly will have a shoreline of approximately 6,800 miles, and the 12 tributary reservoirs, one of 2,200 miles—a total of 9,000 miles. The major mosquito-control problem is presented by areas of shallow water. At normal pool elevation, there will be 54,000 acres with water 3 ft deep or less in the main-river reservoirs and 5,000 acres in the tributary reservoirs, a total of 59,000 acres. With these reservoirs operated for their major objectives—flood control, navigation, and the production of hydroelectric power—conditions are often created under which effective control of anopheline production cannot be maintained with known methods at a reasonable cost. The extent and complexity of the problem in one way has been an advantage, for it has made it not only possible, but essential, to build up an organization representing the several sciences involved to develop more effective and less expensive methods of control.

The area to be flooded must be so prepared as to make conditions unfavorable for the production of anopheline mosquitoes and to facilitate operations for their control. The major credit for initiating such improvements is due to the late G. H. Hazlehurst, formerly Director, and C. C. Kiker, formerly Associate Sanitary Engineer, Division of Sanitary Engineering, Alabama State Department of Public Health. After a survey of the Wheeler Reservoir area, Mr. Kiker recommended that the requirement for complete clearing of a strip 25 ft wide beyond normal pool shoreline be modified to apply to considerably shorter distances, depending upon the character of the shoreline.

It was later estimated that these modifications of state regulations resulted in a saving of approximately $260,000 in the clearing of the Wheeler Reservoir and would have resulted in a much more favorable shoreline for the post-impoundage malaria-control operations had we, as we learned by later experience, carried it one step further into what we term our final conditioning operation. To indicate the nature of some of these modifications—in flat areas complete clearing extends only to the normal pool contour, beyond which the 10-ft zone is cleared of underbrush, timber, and similar debris; at the upper end of indentations, cleaning is extended 15 ft to provide space for piling and burning drift and floatage. On steep shorelines exposed to wave action, clearing is extended 6 to 20 ft to prevent trees from falling in the reservoir as a result of erosion.

With each new project, the malaria control staff have surveyed the area and prepared specifications for marginal clearing and drainage for malaria control. These are based upon Mr. Kiker's original recommendations for Wheeler Reservoir, with additions and refinements as indicated by our increased experience, and are submitted to the state health department for approval.

This experience has shown the need of carrying pre-impoundage preparations of the marginal areas beyond the original clearing. Since the clearing operations extend through two or more seasons, the areas become overgrown with coppice (second growth sprouts from the stumps) as well as dense growths of annual vegetation.

Final conditioning operations are carried out in the fall, before impoundage. These consist in cutting, piling, and burning all coppice and annual vegetation within the zone of normal fluctuation of water level during the mosquito-breeding season; and in cutting any vegetation at lower levels which would protrude above the water surface at low points of the normal operating levels.

This has proved to be one of the most valuable features of pre-impoundage preparation. First applied in the Pickwick Reservoir at a cost of about $37,500, it was the major factor in reducing the cost of the first year's malaria control operations from an estimated $65,000 to an actual $42,000, the original estimate being based upon our experience in the Wilson and Wheeler reservoirs, which did not have the benefit of such thorough

Power Rake Used on Pre-Impoundage Preparation

Machine Adapted from Bulldozer by Welding Large Teeth to the Blade

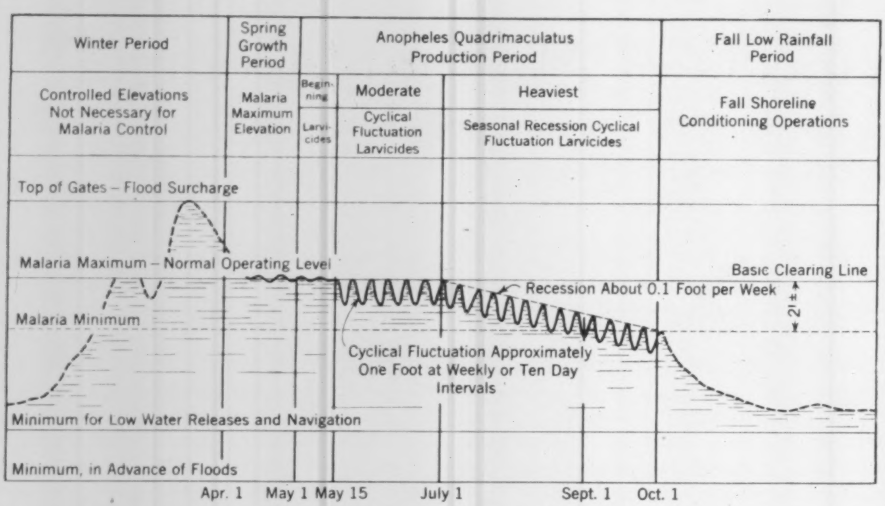


FIG. 1. DESIRABLE FEATURES OF WATER-LEVEL MANAGEMENT FOR MALARIA CONTROL ON MAIN-RIVER RESERVOIRS

preparation. Of more importance, however, was the greater effectiveness of the control measures, made possible by this thorough preparation.

Of major importance in the post-impoundage operations is the fall conditioning of the zone of fluctuation. As the water level changes during the mosquito-breeding season, vegetation invades the marginal areas which are dewatered. If not removed, this emergent vegetation will provide favorable conditions for anopheline production, and the effective application of larvicides will be difficult and expensive. In areas cleared of timber, having numerous stumps, the growth had to be removed by hand tools. With team or tractor-pulled mowers and rakes, the cost could be reduced about 75%. A "low stumping" item was added to the specifications, which requires that in designated flat areas stumps shall be cut to a height of not over 4 in. so as to permit the operation of mowing machines. The additional cost is amortized in about four years by savings in maintenance.

In the upper reaches of tributary streams and in major marginal drainage ditches, posts are set as navigation markers to facilitate the operation of malaria control boats after impoundage. These provide guides beyond the limits of the usual navigation markers.

A resident sanitary engineer, assigned to a reservoir at the beginning of construction, is responsible for making detailed field surveys and indicating the specific areas in which the various sections of the specifications for marginal clearing and drainage shall be applied. The specifications are purposely made flexible and subject to field interpretation in order to secure optimum results at minimum cost.

WATER-LEVEL MANAGEMENT

Proper variation in water level is effective in controlling the production of anopheline mosquitoes by stranding drift and floatage and inhibiting the growth of vegetation, all of which provide food and shelter for the larvae. Dropping the water below the limits of vegetation exposes the larvae to wave action and natural enemies, and makes effective application of larvicides possible—or may even eliminate the need for them.

In constructing Wheeler Dam, the gates were built one foot higher than originally planned in order to provide for "seasonal fluctuation" for malaria control. This "malaria surcharge" was adopted as standard design for the main-river reservoirs.

It was found that vegetation encroached upon the area dewatered during the cyclical fluctuation, but that by combining this fluctuation with a "seasonal recession" instead of utilizing all of the "malaria surcharge" at the beginning of the season, the shoreline was, in general, maintained in advance of the encroaching vegetation. This water level management must necessarily be adjusted to other needs. After several years, a suitable schedule (Fig. 1) has been worked out which considers also the requirements of flood control, navigation, and power production. The flood surcharge phase is recommended for late winter or early spring before the active growing season. After a short period the pool is returned to the normal maximum elevation—stranding the winter's accumulation of drift and flotage. It is held at a relatively constant level during the period of early spring growth to retard marginal vegetation and provide for a cleaner shoreline during the active mosquito-breeding season.

In the late spring, when moderate production of *Anopheles quadrimaculatus* gets under way, the water level is lowered approximately a foot and then returned to the original elevation at weekly or ten-day intervals. This cyclical fluctuation serves to strand eggs and larvae or to draw them out of the protective vegetation so that they are exposed to wave action and the predation of top minnows and other natural enemies. In mid-season, when marginal growth has begun to invade the zone of fluctuation and maximum mosquito production is approaching, seasonal recession is combined with cyclical fluctuation. This seasonal recession, at the rate of about 0.1 ft per week, insures that at the low points the water will be out of the encroaching band of marginal vegetation. Delaying the initiation of seasonal recession until mid-season greatly decreases the total recession and thus narrows the band of annual growth which will have to be removed in the annual shoreline conditioning operation.

Our experience with three different types of water-level management at Wilson Reservoir is illustrated in Fig. 2. In 1935, it was necessary to maintain the reservoir at constant full pool to facilitate construction operations on Wheeler Dam. In 1937, an almost ideal schedule of combined seasonal recession and cyclical fluctuation was maintained, which resulted in practically 90% savings. In 1943, a cyclical fluctuation somewhat greater than usual, but without cyclical recession, was maintained with good results.

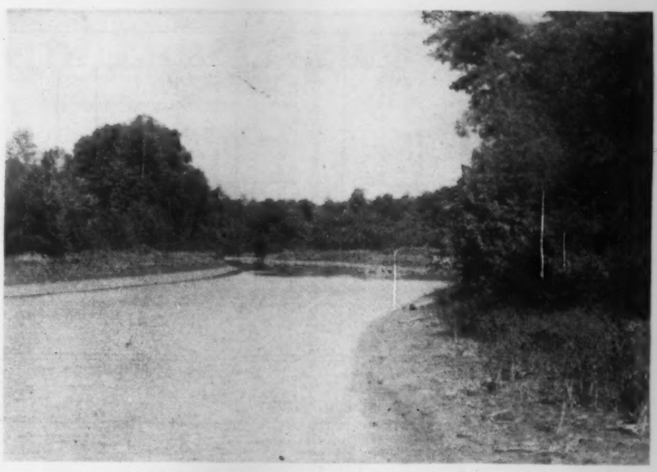
Under normal conditions the storage reservoirs do not present a malaria-control problem. Releases to increase stream flow in the main river are generally begun in the middle of the summer, and the gradual drawdown controls mosquito production without the application of larvicides. However, at times it has been necessary to store water during the summer; and in the case of construction of storage reservoirs as a part of the emergency program to increase power production for war industries, it has been necessary to make the initial filling of reservoirs during the mosquito-breeding season, which is contrary to regulations governing the impounding of water. In 1942, Norris Reservoir was filling slowly during the major part of the mosquito-breeding season. With the waters slowly rising through the vegetation, intensive application of larvicides did not control mosquito production (Fig. 3); but in 1943, the gradual drawdown resulting from drawing from storage brought about almost perfect control of mosquitoes with larvicides applied only on tributary constant-level pools.

PERMANENT SHORELINE IMPROVEMENTS

The Kentucky Reservoir, to be filled in 1944, with a length of 184 river miles, a shoreline of over 2,000 miles, and an area of 159,000 acres at normal pool elevation, presents our most extensive, as well as our most difficult, malaria-control problem. We cannot expect the benefits of cyclical fluctuation combined with a seasonal recession as in the other main-river reservoirs—only those from a seasonal recession of 5 ft through the mosquito-breeding season, with such temporary fluctuations as may result from summer floods. In the central part, the impoundage will inundate the broad, flat flood-plain of alluvial formation to a shallow depth, a combination of circumstances highly favorable to excessive production of *Anopheles quadrimaculatus*.

Malaria is endemic in the reservoir area. Clearly, new approaches to malaria control for projects of this scale and character were necessary. After several years of surveys and studies, a malaria control program has been developed, including diking and dewatering, or deepening and filling extensive flat areas; restriction of land use to daytime occupancy; marginal drainage; and house mosquito-proofing in limited areas. Each measure was fitted to the peculiarities of the shoreline. In addition the usual antilarval measures will be applied in parts of the reservoir where these special measures are not applicable. Permanent shoreline improvements and other special measures, such as mosquito-proofing and restriction of land use to daytime occupancy, are being applied to approximately 70% of the shoreline. The remaining 30% is largely steep, so that usual antilarval measures will give effective control at a reasonable cost.

Annual costs of malaria-control operations, including interest charges on the capital investment for equipment facilities, and shoreline improvements, are expected to be reduced from approximately $337,000 for the usual antilarvicidal program to about $180,000 for the combined program. With this program, there will probably be a gradual reduction in annual maintenance cost. Of far greater importance is the fact that effective control of anopheline production can be maintained, which would not be possible in many sections of the reservoir with the usual antilarval measures.



Arm of Wilson Reservoir, Showing Clear Shoreline at Low Point of Weekly Fluctuation, Unfavorable for Mosquito Production

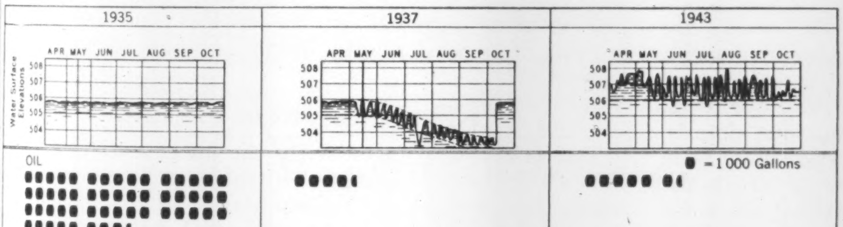


Fig. 2. Comparison of Three Types of Schedules for Water-Level Management—Wilson Reservoir

For the Kentucky Reservoir, diking and dewatering seemed especially indicated for the largest of the flat areas, where drainage runoff was small and advantage could be taken of the usual silt bank of the river in constructing the enclosing dike. In one instance, it was possible to bypass water from a large portion of the drainage area through a diversion canal. Pumps are being installed with sufficient capacity to dewater the diked areas after any expected rainfall. Although flooded during the winter, the land will retain considerable potential agricultural value.

After investigating 19 possible projects, 8 were approved for construction. Savings to offset the cost of construction were made by eliminating clearing within the dikes. More important, by leaving these areas uncleared, the standing timber provided protection against wave action against the fills of relocated highways and railroads, permitting them to be built with steeper slopes and without expensive riprapping, saving about $350,000. The eight dewatering projects have levees totaling about 22 miles in length, requiring about 600,000 cu yd of earth and a total pumping capacity of 660,000 gal per min. Construction will cost about $1,500,000, but will result in a net overall saving of about $80,000. The dewatering projects will eliminate 150 miles of shoreline and about 8,500 acres in the upper 5-ft zone of the reservoir. Of much greater importance, however, is the effective control maintained.

From a maintenance standpoint, the combination of deepening and filling shallow areas is ideal. Mosquito-breeding areas are eliminated and there is practically no maintenance cost. Except for some deep-rooted aquatic plants, for example lotus, which it is anticipated can be controlled readily, the problem of marginal growth and mosquito control has been found to be limited to marginal areas 3 ft or less in depth. Consequently, if the lower half of this zone can be borrowed to fill the upper half, the whole mosquito problem can be eliminated by moving only 25% of the yardage re-

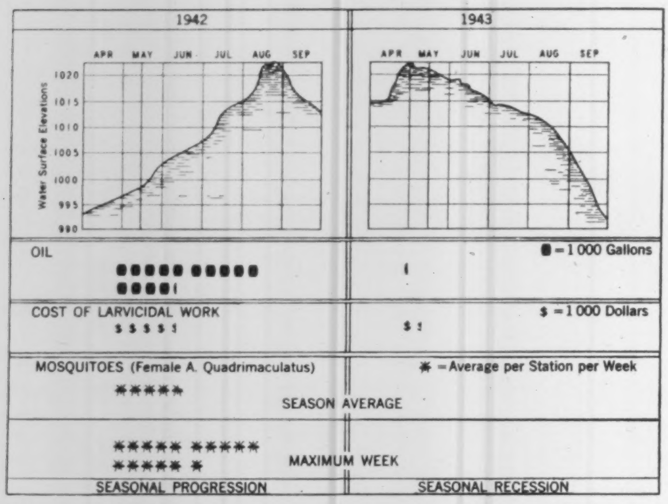


FIG. 3. COMPARISON OF SEASONAL PROGRESSION WITH SEASONAL RECESSION—NORRIS RESERVOIR

quired for either cut or fill alone. But despite this economy, the capital cost usually exceeded that for diking and dewatering in the larger areas, so that it was necessary to limit filling to the smaller areas or those where diking and dewatering would not be applicable.

The nine deepening and filling projects approved for the Kentucky Reservoir will reduce 174 miles of irregular, difficult shoreline to 82 miles, and will permit effective control with the usual antilarval measures, eliminating over 1,700 acres of problem areas. It will involve moving about 1,700,000 cu yd of earth. The estimated annual saving in malaria control operations is $34,000 in out-of-pocket cost, and $8,000 including interest on the estimated capital cost of $850,000. Again it is emphasized that effective anopheline control is more important than the monetary saving.

Surveys are being made with a view to developing a program of gradually "building out" problem areas in other main-river reservoirs in a similar manner.

MOSQUITO-PROOFING HELPS

Mosquito-proofing, employed as a secondary measure, tends to control malaria in two ways, (1) by preventing the access of non-infected mosquitoes to infected persons, and (2) by protecting well persons from infected mosquitoes. It involves not only providing screens for doors and windows, but also closing all openings through which mosquitoes can enter a house. Where the cracks are extensive, tar-paper roofing is laid over the floor and a heavy kraft paper is tacked on the walls. Plywood screens are made to fit tightly over fireplace openings. Considerable study has been made of various details.

In this program approximately 900 houses have been mosquito-proofed in the Wheeler area, with 300 in the Guntersville and 250 in the Kentucky reservoir areas proposed. In addition, an emergency program for approximately 900 houses is under way to permit filling of the Kentucky Reservoir during the mosquito breeding season and avoid further delay in the production of power.

Originally work in the Wheeler Reservoir was carried out by agreement with the Alabama Department of Public Health, which in turn made contracts for the actual work. At present considerable difficulty has been experienced in procuring material, and some compromises and substitutions have been necessary. The Kentucky Reservoir work is in cooperation with the State Health Departments of Kentucky and Tennessee, but is done by the Construction and Maintenance Division of the Authority, which has developed an effective organization, particularly for constructing doors, using machine tools and assembly-line technique.

WILDLIFE CONSERVATION DOVETAILS

A controversy existing for years between wildlife conservationists and those interested in malaria control had potentialities for being greatly localized and intensified when the middle section of the Wheeler Reservoir, then our most difficult malaria-control problem, was established as a wildlife refuge under the control of the U.S. Fish and Wildlife Service. Two seasons of field investigations by a joint committee were carried out to note what effect, if any, the malaria-control program had on fish and water fowl. The major results, in addition to an acknowledgment that the malaria control did not have as serious an effect as had been feared, was the development of a better mutual understanding.

The first diking and dewatering project is to be in the Wheeler refuge area, a joint activity of the U.S. Fish and Wildlife Service and the TVA. Three contiguous malaria problem areas were originally connected with the Tennessee River by narrow outlets through the high silt-formed river bank. Control structures will be built at each of these outlets, with interior drainage carried to a pumping station. By dewatering during the mosquito-breeding season, effective mosquito control can be maintained, while the conservation interests can eliminate undersirable aquatic growths and replace them with suitable plants. In the fall, the areas can be refilled, so that they will serve as better resting and feeding places for water fowl than in the past.

In developing the project, at least a dozen points of mutual interest between the wildlife-conservation and the malaria-control programs have been pointed out. Hence it appears that emphasis might well be placed on the common interests rather than on the points of conflict. For example, bitter criticism had been made of the fluctuation of water level for malaria control and its serious effect on fish spawning. The Authority's ichthyologists have stated that the drainage of marginal depressions is a much greater benefit to fish by saving them from being stranded in shallow pools than the fluctuation is a detriment. Furthermore, the phase of relatively constant pool level for malaria control holds the water levels up during the fish spawning season and prevents the eggs from being dewatered before they have had a chance to hatch; also it provides the young fish with food and shelter during this period. The fall shoreline clearing removes woody species and favors the growth of annual plants which are valuable food for water fowl.

INFORMATION WIDELY UTILIZED

The TVA was faced with the most extensive and difficult problem of malaria control on impounded waters which has arisen in this country. In attempting to develop an effective and economical program, it has made some definite contributions. It has furnished information on equipment and supplies to other organizations, both at home and abroad. Men from our armed forces and from other countries have come here to observe its work and to secure short periods of field training. Former employees of the Authority—doctors, biologists, engineers, and engineering aides—are with the armed forces in the South Pacific, Latin America, Africa, and the Far East. It is gratifying to those of us who are still on the home front to know that we are making this small contribution in the global war against our third enemy, the malaria mosquito.

Peru's Ocean-to-Amazon Highway

By Julian L. Schley, M. Am. Soc. C.E.

Major General, U.S. Army; Director, Transportation Division, Office of Inter-American Affairs, Washington, D.C.

An outstanding wartime accomplishment of the Republic of Peru, and an important contribution to the Allied war effort, is the completion of the strategic Ocean-to-Amazon highway, which now connects Peru's Pacific coast ports with the upper Amazon Valley. This valley is today the western hemisphere's source of natural rubber, barbasco, and other strategic materials.

The first section of the Lima–Pucallpa Highway, that from Lima to the central plateau (see Fig. 1), is known as the Central Highway and has been completed for several years. It is asphalted for 116 miles, or as far as Oroya. This is one of the most daring pieces of highway engineering in the world, for in the first 87 miles of its length it climbs through a series of canyons, unbelievably narrow and steep, and crosses the Anticona Pass at 4,843 meters, or almost 16,000 ft above sea level. At one point the road climbs in a spiral, crossing itself twice by bridge in a great figure-eight, the only loop of this kind in the Americas.

At the top of the pass the road is over a thousand feet higher than Mont Blanc. Here it is cold, and the air is very thin. The highway continues at an average elevation of over 13,000 ft past Cerro de Pasco. It then dips into and out of a series of lower valleys.

Continuing eastward from Huanuco (Fig. 1) the highway crosses some of the lesser ranges of the eastern Andes and drops down into the tropical valley of the Huallaga River to the frontier town of Tingo Maria. A few years ago this was only a collection of thatched huts marking the end of the trail. Today it is on its way to becoming an important town. Tingo Maria now has a new hotel with accommodations for 48 guests; a new and up-to-date tropical hospital with 40 beds; a government agricultural experiment station, with buildings costing $160,000; quarters for various government officials and administrative officers; a modern school, two sawmills, warehouses and stores, and an active traffic on the Huallaga River.

United States technicians have joined with Peruvian experts in establishing the agricultural experiment station at Tingo Maria. Among other products, this station is interesting itself in the production of quinine, kapok, quinoa, and barbasco, all of which are native to the region, as well as tea, jute, and abaca (from which is obtained manila fiber).

Beyond Tingo Maria the highway almost loses itself in the heavily forested ridges of the Blue Mountains. Here one of the most romantic episodes in its construction took place. The problem was how to get out of a valley 2,200 ft above sea level, over a range 7,000 ft high, and down to the River Ucayali. No pass through the mountains could be found. Someone then remembered that, in past centuries, the Franciscan missionaries had explored much of this country in their efforts to convert the Indians. How did they get through? The engineers dashed back to the dusty church archives in Lima. In the spring of 1937, engineer Federico Basadre found the long-forgotten records of the Franciscan missionary Fray Alonso Abad, which covered 12 closely written manuscript volumes. Here was a record of a long and exhausting search through the dark and uninhabited jungle for a break in the Blue Range and a way through to the Amazon—but let the record speak:

"In the spring of 1757," says this old diary, "we organized a new expedition, leaving the Indian village of Cuchero on May 4 with 17 Indians and arriving on May 15 at Tulumay, and, following the directions of a previous expedition, we discovered, on the 25th day of May, the 'Paraja' where a passage seemed to open in the broken country which led to a gorge or canyon leading in the direction of the forest-covered Pampas of Sacramento (or Amazon lowlands)." It must be remembered that this little band was groping its way through an almost impenetrable tropical jungle.

On July 22, 1937, engineer Basadre, following the exact directions written nearly 200 years before, found the same canyon which the Yuracyacu River had cut in an easterly direction through the Blue Range. No other person had been through this gorge in nearly two centuries, for this part of Peru is uninhabited. This *boqueron*, or canyon, which has been named after Padre Abad, is a deep, narrow transverse crack through the range, brought about by some gigantic seismic disturbance of the past. The crack is a little less than 3 miles long, not over 300 ft wide in places, and 6,000 ft deep. The bed of the gorge is 1,400 ft above sea level. Three tunnels and three bridges were required to get the road through beside the river.

ON THE UCAYALI

Leaving the Boqueron, the road crosses the River Aguaytia, where a bridge 2,560 ft long is yet to be erected—the crossing is now effected by a ferry. The road then continues across the forested lowlands to Pucallpa on the River Ucayali, a tributary of the Amazon. Pucallpa, only a frontier village 5 years ago, now bids fair to become the metropolis of eastern Peru. It already has an airport, a hospital, a school, and other modern buildings. River steamers towing barges now ply between Pucallpa and Iquitos, a distance of some 650 miles—taking three days—and ocean steamers up to 6,000 tons come up the Amazon as far as Iquitos, 2,300 miles from the Atlantic.

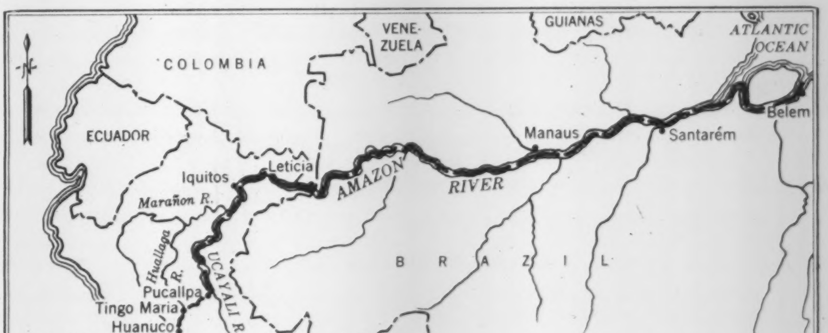


Fig. 1. Peru's Ocean-to-Amazon Highway

The opening of this route is of great strategic importance, apart from its economic value. It is already described as a vital auxiliary of the Pan American Highway system. A regular overland mail and parcel-post service between Lima and Iquitos has been established. The first mail truck left Lima on the morning of September 8, 1943, and according to newspaper reports, made the 522-mile run to Pucallpa in 14 hours and 20 minutes, or an average of better than 37 miles an hour.

At Pucallpa the mail is placed on board a river steamer for the three-day, 650-mile run to Iquitos. Passenger buses make the run between Lima and Pucallpa in two days, with an overnight stop at Huanuco. A transportation company has been organized to handle shipments of merchandise between Lima and Iquitos. The wartime completion of this highway, which was begun several years ago, is credited to the driving force of Don Carlos Moreyra y Paz Soldano, Peru's dynamic Minister of Public Works and Development, who has made this task a No. 1 objective of his administration.

RESOURCES OF THE REGION

This Amazon Valley region is rich in rubber. With the aid of United States credits, there has been established a Peruvian Amazon Corporation, which will develop other tropical products of strategic importance, such as barbasco and jute. A most significant phase in the development of this new region, and one which has been largely overlooked in the press of world affairs, was the discovery of oil, some 6 years ago, at a point about 50 miles upstream from Pucallpa on the Pachitea River and only about 20 miles from the line of the present new highway. As far as is known, this is the only dependable supply of petroleum in the Amazon Valley. A small refinery has been installed here and supplies over 6,000 bbl a month of gasoline and oil for river transport.

While Peru's Amazon Valley area—equal to two-thirds the total area of the nation—is short on highways, it is abundantly supplied with waterways. There are said to be no less than 22,000 miles of navigable river channels on its nine great rivers and their tributaries. For this reason eastern Peru needs motor boats more than motor cars. At least 5,000 motor-powered vessels of various types and sizes will be required, it is estimated, to serve this region in which scarcely a hundred such boats are operating today.

HIGHWAYS OF PENETRATION

The "highways of penetration," aimed to connect Peru's coastal and plateau regions, with the Oriente, or the Amazon Basin, are (1) the Pucallpa Highway just described; (2) the Olmus–Maranon Highway in the north, now well under way; (3) the Urcos–Marcopata–Madre de Dios Highway; and (4) the Huambutio–Paucartambo–Madre de Dios Highway. The last two are in the Department of Madre de Dios and branch off to the east from the two named stations on the Cuzco–Puno railroad. Other highways of penetration are being considered, but work on them has not yet begun.

The Olmus–Porculla–Rio Maranon route, Peru's northern highway of penetration, named "Ruta Mesones Moro" after its explorer and discoverer, starts from the city of Olmus on the Pan American Highway in the Department of Cajamarca, 536 miles north of Lima. It crosses the main range of the Andes of the Porculla Pass, 7,072 ft above sea level—the lowest pass across the main Andes in all Peru. This road follows the Quebrada de Tierras Negras and Huallapampa as far as the River Huancabamba, 49 miles from Olmus. From this point it follows the left bank of the Huancabamba as far as its outlet in the Maranon River, terminating at the town of Bellavista, 143 miles from Olmus, and opening up magnificent agricultural territory between Jaen and Bellavista at elevations averaging 2,000 ft above sea level.

This highway, a later extension of which will be carried 65 miles to the Pongo de Manseriche, the famous gorge in the upper Maranon, is now open for normal traffic for a distance of more than 60 miles from Olmus, and preliminary engineering work has been carried much farther. It is hoped that by the end of the present year it will be opened to traffic as far as Bellavista, when work will be immediately inaugurated on the 65-mile extension to the Pongo de Manseriche.

The Maranon is navigable both above and below the 7-mile gorge or "Pongo," which is full of rapids. From Iquitos to the Pongo, some 450 miles, it is navigable by steamers drawing up to 6 ft of water, and above the rapids by smaller crafts drawing 2 ft of water.

The Urcos Highway drops down rapidly from the plateau, near Cuzco, 12,000 ft above sea level. Then it traverses the valley of the Marcapato River through Quince Mil, a community with an airport and supply base for the hundreds of gold miners of that region, past Palcamayo to the Nusiniscato River, 190 miles from Urcos. Plans call for it to be extended 30 miles farther to the Inambari, an affluent of the Madre de Dios River. Rubber is now being brought out from the Madre de Dios by pack train, to the end of this new highway.

The Huambutio Highway branches off from the railroad station of that name a little to the north of Urcos, leads down into the valley of the upper Madre de Dios via Paucartambo, through the 15-mile canyon of the Yanamayo River, then down the River Pilcopata and eventually to the River Carbon near Itahuania, a total of 162 miles, more than half of which is now constructed. Exploration parties have reported large coal deposits, oil seeps, sulfur hot springs, signs of gold, and lots of rubber trees in the region beyond the highway's end.

Other highways, not yet begun but scheduled for future construction, include the route from Satipo to the Perene Valley and eventually to the River Ucayali; that from Tambo to the Apurimac River; that from Cuyu-cuyu to Sandia and the rich gold regions thereabouts; and that from San Luis de Shuaro, via Oxapampa to the Pozuzu and Pachitea rivers.

In 1927 Peru had only 7,500 miles of good highways; today the mileage exceeds 15,700. The Pan American Highway runs for 1,761 miles through the length of Peru; nearly all of this is completed, and nearly 90% is either hard-surfaced or asphalted.

RAILROADS AND SHIPPING

There has been virtually no railway progress in Peru during the last 15 years, because of the recent depression, the high cost of building railroads, and the idea that they would gradually be displaced by motor transportation. This last idea has been dispelled by the events of the war, and it is recognized that roads and railroads are complementary. The possibility of electrification of railroads has been considered. In February 1944 the Peruvian Government appointed a commission of engineers to develop an integrated plan for extension and improvement of the railroads. Cable railways also are of importance in Peru for the transportation of minerals.

The total maritime coastwise traffic of Peru ran to about 2,250,000 tons per year between 1937 and 1941 and has not grown since in consequence of wartime shipping scarcities. At the completion of the four great interior highways, river shipping will undoubtedly become of great importance from the navigable harbors of the Maranon, the Ucayali, and the Madre de Dios rivers.

Do Rivets Retain Their Initial Tension?

By Wilbur M. Wilson, M. Am. Soc. C.E.
Research Professor of Structural Engineering, University of Illinois, Urbana, Ill.

Comprehensive tests indicate that rivets which have been in service tend to lose the tension imparted at driving. In the case of a short rivet, completely filling the hole, this loss of tension may be relatively unimportant. On the other hand, with a long rivet, which in many cases does not fill its hole at mid-length, tension developing friction between members at the joint is indeed important. In this account Professor Wilson records results of tests made at the research laboratory of the University of Illinois, under his direction.

Structural joints fabricated by riveting have proved highly satisfactory in service. Although one of the factors that determines the strength of a riveted joint is the strength of rivets in shear, it would be highly desirable to have enough tension in the rivets to enable them to carry the load by virtue of the friction between the plates, thus relieving the rivets of shear and the accompanying flexure.

It is generally known that there is tension in a hot-driven rivet resulting from the contraction accompanying its cooling. Early tests of riveted joints, which in general had rivets with a short grip, showed that slip took place at a shear considerably below the design load. Later tests of riveted joints with rivets of longer grip, 3 in. or more, showed that initial slip did not take place until the shear on the rivet exceeded the design stress.

The extent to which the shear on a riveted joint is resisted by the friction between the plates depends upon the tension in the rivets. Laboratory tests made at the University of Illinois, Engineering Experiment Station (Bulletins 210, 302, and 337), show that carbon-steel rivets with a grip of 3 in. or more consistently have a tension of 20,000 to 30,000 lb per sq in. The shear required to produce slip between plates clamped together by such rivets is of the order of 20,000 to 25,000 lb per sq in. of rivet section, a value considerably in excess of the usual working stress for carbon-steel rivets. The tension in some low-alloy steel rivets with a 3-in. grip varied considerably for the individual rivets and was as low as 4,000 to 10,000 lb per sq in. for some. The shear required to produce slip between the plates was correspondingly erratic and low. The tension in low-alloy steel rivets with a grip of 5 in. was consistently high. In general, the tension in the rivet increased with the grip in both magnitude and uniformity, and the maximum value was somewhat less than the yield point of the steel.

Table I. Tension in $^7/_8$-In. Carbon-Steel Rivets After Approximately Forty Years of Service
(Grip of Rivets, $3^7/_{16}$ In.)

First Series

Rivet No.	Tension, Lb per Sq In.	Condition of Rivet*
1	4,200	. . .
2	6,400	Tight
3	12,600	Tight
4	7,000	. . .
5	7,200	Tight
6	11,500	. . .
7	5,400	. . .
8	5,100	Tight
9	9,900	. . .
10	11,000	Tight
11	13,400	Loose
12	2,700	Loose
Average........	8,030	

Second Series

Rivet	Tension, Lb per Sq In.
A	4,890
B	9,330
C	9,770
D	1,290
E	3,000
F	1,800
G	2,740
H	9,100
J	5,230
K	4,970
L	9,940
M	6,510
O	9,770
P	3,430
Q	7,280
R	3,600
Average......	5,790

A short, properly driven rivet will fill the rivet hole, but probably will have a low tension. Unless the end of a long rivet is cooled before driving, or unless it is tapered, it probably will not fill the hole at mid-length, but it will have a high tension. A rivet that fills the hole will be satisfactory in service, so also will be one that has high tension—if it retains its tension.

Although tests have been made to determine the tension in rivets shortly after they are driven, the writer knows of no published data giving the tension remaining in the rivets after extended field service. A few years ago the Nickel Plate Railroad removed short deck-plate girders from bridges that had been built about 1900, because the increase in the weight of the rolling stock has been so great that the girders were not strong enough to carry the traffic. The ends of the girders were cut off and new end stiffeners were riveted on, thus making shorter girders with a load-carrying capacity sufficient to carry the heavier loads because of the decreased length of span. Through the courtesy of the late G. H. Tinker, M. Am. Soc. C.E., then Bridge Engineer of the Nickel Plate Road, the ends of the girders which had been cut off were sent to the writer for experimental purposes, the one test particularly desired being the determination of the tension remaining in the rivets.

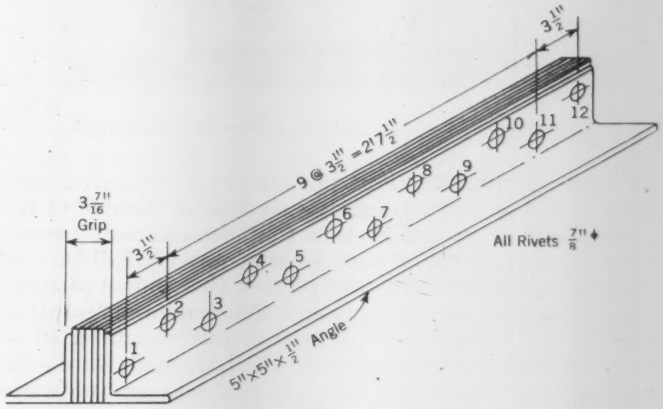

$3\frac{1}{2}''$
$9 @ 3\frac{1}{2}'' = 2'7\frac{1}{2}''$
$3\frac{7}{16}''$
Grip
$3\frac{1}{2}''$
1
2
3
4
5
6
7
8
9
10
11
12
All Rivets $\frac{7}{8}''$ ♦
$5''\times5''\times\frac{1}{2}''$ Angle

Fig. 1. Specimen Used in Rivet Tension Tests

A short length of the end stiffeners cut from a girder is shown in Fig. 1. The rivets, which had a nominal diameter of $^7/_8$ in., extended through seven layers of steel and had a grip of $3^7/_{16}$ in. Rivets 1 to 12 were tested for tension. Before the test, an experienced machinist tapped each rivet with a hammer to determine by this field-inspection method which rivets were loose and which were tight. The end stiffeners were then cut transversely with a hack saw between each pair of adjacent rivets so as to produce twelve blocks, each containing a single rivet connecting the seven layers of steel. Next a steel pin was inserted in each head of each rivet,

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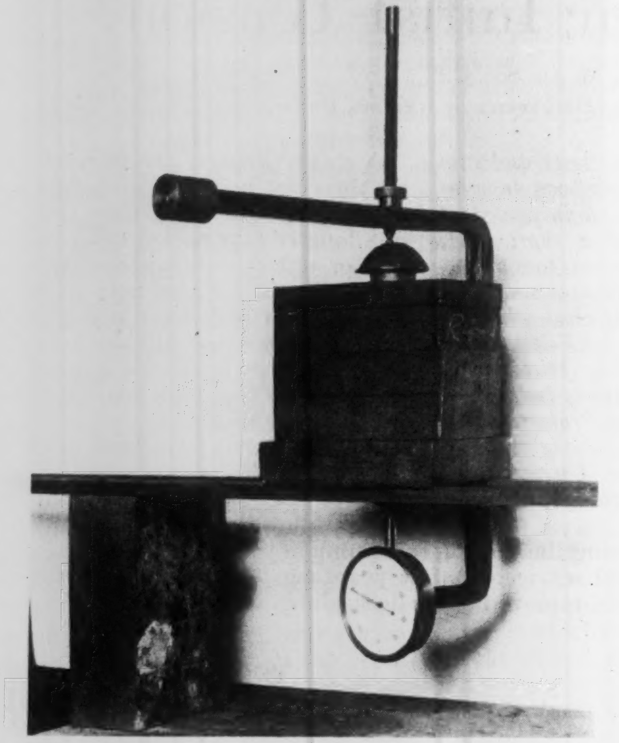
* Inspected by tapping with hammer.



INSTRUMENT FOR MEASURING RECOVERY OF RIVETS

as shown in Fig. 2. This pin extended through a hole in the head and fitted tightly in a hole in the end of the rivet shank in such a manner that the pin would move with the end of the shank. There was a small hole in the outer end of each pin to receive the conical point of the instrument used to measure the change in length of the rivet. The instrument was counterweighted so as to balance on a conical point in the bar, as shown in the accompanying photograph. The dial was graduated to 0.0001 in., and the instrument was checked against a standard bar after each set of readings. The specimen, standard bar, and instrument were placed together in a constant-temperature room several hours before readings were taken in order to eliminate errors due to temperature changes.

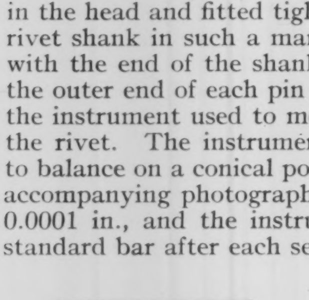


FIG. 2. RIVET PREPARED FOR INITIAL TENSION TEST

TEST PROCEDURE

The length, out-to-out of pins, was measured for all the rivets. The tension in each rivet was then relieved by putting the specimen into a lathe and machining away the plate under the head of the rivet. A specimen with a stress-relieved rivet is shown in the photograph. The specimens were then stored in the constant-temperature room for several hours and the length out-to-out of pins was again measured. The change in length out-to-out of pins was the recovery of the rivet that resulted from relieving the stress in a length equal to the grip. This recovery was converted into stress on the basis that E = 30,000,000 lb per sq in.

The results of the tests are given in the first series of Table I. It is of interest to note that the tension in the rivets varied from a minimum value of 2,700 to a maximum of 13,400 lb per sq in. It is also of interest to note that a rivet having a tension as low as 5,100 lb per sq in. was rated "tight" by the hammer test and that another rivet with a tension of 13,400 lb per sq in. was rated "loose" by the same test and by the same workman.

The rivets in the end stiffeners of another similar girder were also tested for tension (see Table I, second series). Rivets "E" to "M" were near one end of the stiffeners, and rivets "O" to "R" were near the other end. The tension was determined from the recovery, using the technique that has been described. Both the minimum and maximum values for the second group of rivets were slightly less than the corresponding values for the first group. The range between the maximum and the minimum was about the same for the two groups.

SOME TENSION RETAINED

These tests showed that some rivets retained a considerable tension after approximately 40 years of service, but that other rivets had practically no tension in them. The service to which these rivets were subjected, connecting end stiffeners to the web of deck-plate girders of a railroad bridge, would seem as likely to dissipate the stress that might have been in the rivets as any service that could be devised except a reversed load stress so great as to cause slip between the connected parts.

The tension that existed in the rivets at the time they were driven is not known. Modern shop practice, which generally precludes the use of shop assembly paint, probably would produce an initial tension of the order of 20,000 to 25,000 lb per sq in. in a carbon-steel rivet with a 3 7/16-in. grip. At the time the test girders were fabricated, it was common practice to use assembly paint on pieces that were shop riveted. If that practice was followed in the fabrication of these girders there would be a coat of paint on the surfaces of each of the two pieces that were in contact, a total of 12 coats of paint between the rivet heads, not including the coats immediately beneath the heads. After the rivet connecting the plates which made up a specimen had been machined away, the plates were separated and samples of the dust and scale on the interior surfaces were subjected to a qualitative chemical analysis. The tests of all samples showed that lead was present, indicating that assembly paint was probably used in fabricating the girders. It is not unreasonable to suppose that twelve layers of paint might be compressed enough to reduce appreciably the magnitude of the tension that would otherwise be produced in the rivets. A total reduction in thickness of 0.001 in. for the 12 layers would reduce the tension of rivets with a 3 7/16-in. grip by 13,000 lb per sq in.

In a letter to the writer, C. E. Webb, M. Am. Soc. C.E., Division Engineer, American Bridge Company, Chicago, writes, "The omission of paint for contact surfaces we have found aids in securing tighter rivets. The hot rivet, acting on the paint, produces a powder-like substance between the plates which results in loose rivets."

It is probable, therefore, that the initial tension in these rivets was considerably less than the tension that would be produced under modern shop practice. In any case, the tests indicate that stresses as high as 12,000 to 13,000 lb per sq in. existed in some rivets after approximately 40 years of service.

Omaha Airport Runways Resist Flood Damage

Investigation Discloses Remarkable Recovery of Strength After Waters Recede

By W. H. Campen, Assoc. M. Am. Soc. C.E., *and* J. R. Smith
Respectively, Manager and Chief Chemist, Omaha Testing Laboratories, Omaha, Nebr.

BETWEEN April 12 and April 29, 1943, the Omaha, Nebr., municipal airport was completely flooded. During the period water rose to a depth of 7 ft over the landing and taxi areas. As the flood abated, considerable concern was expressed over the damage that doubtless had been done. A complete investigation of surface and subgrade strengths was ordered, and the Omaha Testing Laboratories were engaged for the work. Seventeen days after the flood subsided, the 6-in. compaction-stabilized sand-gravel-clay base course and the 12-in. compaction-stabilized subbase course were sampled at 500-ft intervals, and observations were made of the condition of the 2 to 3-in. asphaltic surface and of the subgrade to a depth of 4 ft. Density and moisture contents were determined and load-bearing tests were made.

As a result of the buoyant force due to entrapped air beneath the surface of the runway, many air blisters formed during the flood. Some of these were 6 ft in diameter and reached a height of about 12 in. at the center. As the water receded, all the blisters flattened down to the original position with no apparent damage. Only one of the blisters broke, requiring replacement of the surfacing. This repair amounted to about 9 sq yd out of a total of about 400,000 sq yd.

Investigation of the subgrade showed that water had entered at all locations tested. The effects varied with the composition of the material. Sandy areas were filled with water but no loss of strength resulted. Heavy clays were saturated, with appreciable loss of strength, while silty materials lost practically all supporting value when saturated. No swelling occurred in any of the materials.

The moisture and density tests on the base and subbase courses indicated that these courses retained their original densities to a high degree, as about 85% of the samples had a density as great as, or greater than, when constructed. The tests further indicate that the water-holding capacity of compacted soil mixtures can be restricted, as shown by the fact that about 85% of the samples contained only as much, or less, water than their designed capacity.

The load-bearing tests made in May 1943 indicated that the runways had lost about 20% of their pre-flood strength, as based on tests made in the fall of 1942. This loss was attributed to saturation of the natural subgrade.

Four months after the flood, in September 1943, load-bearing tests were repeated at 17 locations. At 13 of these the materials had regained all their pre-flood strength, and at the other 4 locations, 90% of their former strength.

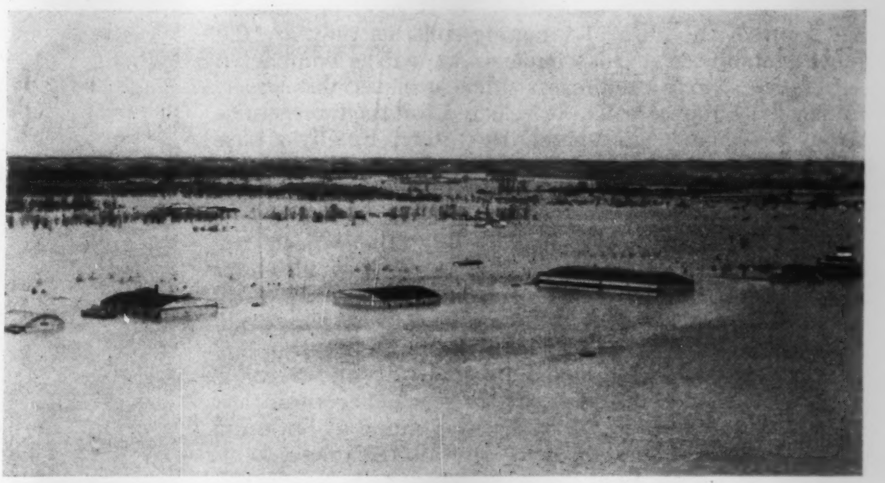
In order to better explain the behavior of the runways during the flood, it is pertinent to discuss the factors involved in the design of the flexible pavements. First of all, flexible pavements are so called because their surfaces can be deflected from 0.25 to 0.5 in. without causing failure. Rigid pavements, on the other hand, cannot be deflected much more than 0.05 in. without cracking. The type of deflection referred to is that caused by circular testing plates.

In designing flexible pavements, it is necessary to consider three major factors: (1) the natural subgrade strength, (2) the strength-imparting power of superimposed layers of densified soil mixtures and bituminous mixtures, and (3) the durability of the densified soil mixtures. In attempting to measure the strength of a subgrade or flexible surface, the designing engineer is confronted with several problems. These will be discussed in detail. Probably the most significant is the variation in strength with the size of the testing plate. Some years ago, W. S. Housel announced that at any given deflection or deformation the load-bearing value of subgrades varies directly as the perimeter-area ratio of the testing plate.

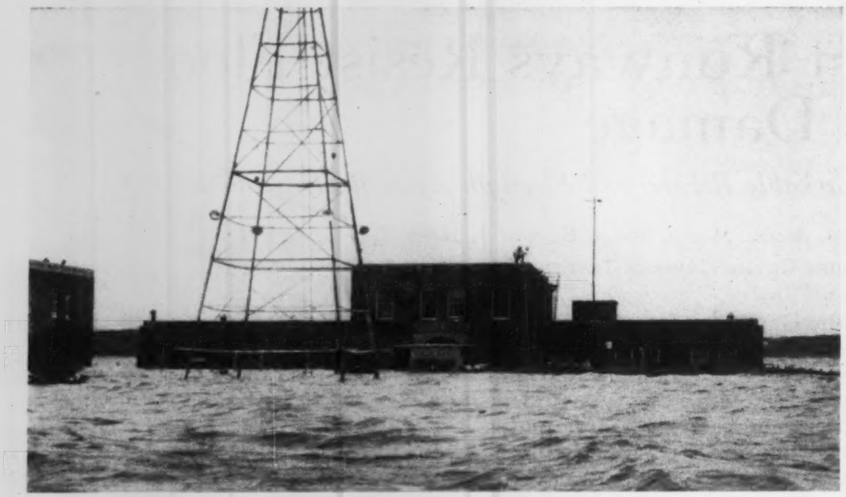
In 1941 the Omaha Testing Laboratories had an opportunity to make 11 sets of load-bearing tests for the U.S. Engineers in connection with the construction of runways at Fort Crook. Both the laboratory and the field tests showed that compacted mixtures follow the perimeter-area law. This is very gratifying as it makes it possible to estimate large plate strengths from the data obtained with two or three smaller plates.

The deformation at which to make strength observations is another vital matter. Strength increases as deformation increases, and for that reason it is desirable to allow as much deformation as possible in design. On the other hand, deformations in excess of $^1/_4$ in. cause fine cracks which are the beginning of failure. For the present we are using a $^1/_4$-in. deformation for design purposes.

It has been shown rather conclusively that the contact area of a large pneumatic tire is equal to its load in pounds divided by its air pressure in pounds per square inch. Furthermore, this contact area is assumed to be a



Completely Inundated Airport at Crest of Flood—Runway Area in Foreground



WATER ROSE TO A MAXIMUM OF 8 FT IN VICINITY OF ADMINISTRATION BUILDING

circle. It is customary at present to use rigid circular steel plates to represent tires of equal contact areas. In regard to impact in the landing of planes, it has been found that, under ordinary conditions, this load is less than the weight of the plane. Even for bad landings, the total impact is not more than 125% of the static load.

To evaluate the subgrade, it is tested with a plate representing the tire-contact area at $^{1}/_{4}$-in. deformation. If more information is desired, load-deformation readings can be taken with two or three plates until a $^{1}/_{2}$-in. deformation is obtained. With these data, the subgrade can be rated for any wheel load at any deformation up to the limit used.

The most important part of a subgrade evaluation is the selection of the worst anticipated condition. Obviously, if the subgrade is expected to become saturated with water, it should be tested in this condition. To produce this condition, we place from 12 to 24 in. of sand above the subgrade and then keep the sand saturated for 4 or more days. This procedure submits the subgrade to the action of water while it is under a load representing the weight of the pavement. Finally, the sand and water are removed and the subgrade tested. In our opinion this type of test should be made only when conditions demand it. In other cases the subgrade should be tested as found, or after some suitable modification has been made.

Information must also be obtained on the strength-imparting ability of soil and soil mixtures which might be compacted above the subgrade. It is good practice to use some of the natural subgrade soils, as they are the most economical. This course is known as compacted subgrade. Next, a course of subbase material is superimposed. Subbase soils are selected for their resistance to volume changes and capillary water. Finally a base course is constructed. Bases consist of some suitable clay binder and well-graded sand-gravels or rock mixtures. All these courses are compacted and tested in 6-in. layers. The number of layers of each depends on the project.

The strength of the layer combination would have very little significance if the pavement could not withstand detrimental volume changes or softening by capillary water. For these reasons it becomes of prime importance to submit compacted soils to drying, freezing, and capillary action. Soil mixtures which contain less than about $1^{1}/_{2}$ to $3^{1}/_{2}\%$ of air by volume at optimum water content, do not take up any appreciable amount of water in 7 days. On the other hand, soils which contain more than $1^{1}/_{2}$ to $3^{1}/_{2}\%$ of air do take up water, and the amount is governed by the percentage of air present. This observation has tremendous importance in the design of mixtures for compaction stabilization. It should be emphasized that the percentage of air, or air-void content, is the controlling factor in stability. If the water-holding capacity is limited, the degree of softening is also limited, and therefore the mixture can be relied upon to furnish the design strength at its wettest condition. Our field observations in recent years lead us to conclude that most of the failures in soil stabilized areas have been due to a lack of proper compaction, which is another way of saying that the water-holding capacity was greater than anticipated.

Compacted soils may absorb water even though their air-void content is very low, if during absorption they increase in volume by swelling. All unconfined samples will behave thus, but when tested under conditions similar to those in the field, they do not swell when properly compacted.

Since the actions of drying and freezing can and do disintegrate compacted soils, attention must be given to their behavior in these respects. We find that mixtures can be prepared which will show no detrimental volume changes on being dried or frozen.

In applying the results obtained from all the tests outlined, it is necessary first to consider the conditions to which the roadway or runway will be subjected. For instance, if the densified layers are apt to be subjected to the influence of water plus freezing, they should contain a very low percentage of voids at optimum water content and should show very little volume change on freezing. If they might lose most of their water, they should show little shrinkage on drying. If they might be subjected to water but not to freezing, they need to be low in air voids but the volume change on freezing would not be important.

The authors wish to give credit to Harry Knudsen, who is in charge of the Omaha Municipal Airport, for his cooperation in all the investigations made.

This paper was presented by Mr. Campen before the Nebraska Section of the Society, and has been revised somewhat for publication.

SECTIONS OF THE ASPHALTIC SURFACE WERE REMOVED TO MAKE LOAD-BEARING TESTS

Engineers' Notebook

Suggestions and Practical Data Useful in the Solution of a Variety of Engineering Problems

Rational Design of Spaced Timber Columns

By CHARLES MACKINTOSH

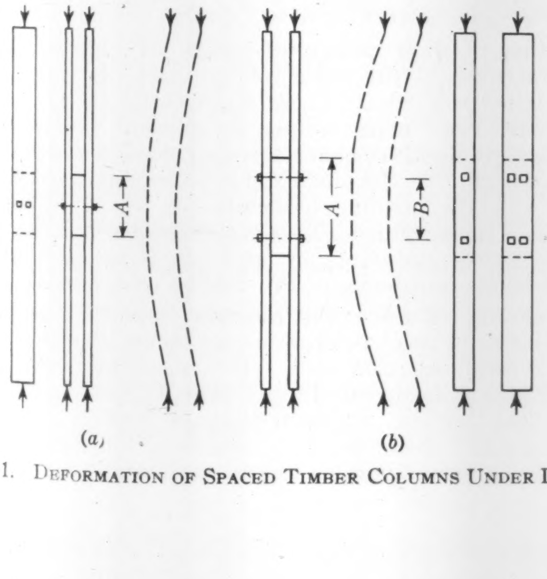
MACKINTOSH AND MACKINTOSH, CONSULTING ENGINEERS, LOS ANGELES, CALIF.

THE larger structures being built of timber during this critical time present problems to the designer, who is often handicapped by the lack of comprehensive analysis in literature. The designer is usually handicapped also by the lack of time for the personal research which would provide satisfactory solutions.

Spaced columns are commonly used in compression chord members in large trusses or timber frames, as compression web members or as posts. The problem of analysis falls naturally into two parts—the effect of central fill blocks and the effect of end conditions.

Consider first the effect of the central fill block in a column where both members have separately pinned ends, as in Fig. 1. When one or more bolts are placed at the center of a block at mid-column height, as indicated in Fig. 1 (*a*), the columns may deflect together in the same direction. If the bolts and washers are adequate to hold the left member snugly against the length of the block, the effective moment of inertia of this column member will be increased in the distance A by approximately the moment of inertia of the block. The moment of inertia of the right member is not increased. There is then interaction between the two columns of unequal stiffness.

If the bolts in the fill block are placed at some distance, B, apart along the length of the columns, Fig. 1 (*b*), both of the twin columns are stiffened. Where the fill block is long, additional bolts, nails, or other fastenings may be used to make the columns keep contact with the faces of the fill block throughout its length. Since the ordinary fastenings do not prevent small movements of the members relative to each other, the moment of inertia of the spaced column will then be $I_L + I_R + I_B$ in the central region, and $I_L + I_R$ outside of this central region. Here I_L is the moment of inertia of the left-hand member; I_R the moment of inertia of the right-hand member; and I_B the moment of inertia of the block. The stiffened portion may with sufficient accuracy be considered to be of length $(A + B)/2$. Where the fill block is glued in place, the stiffness will be increased, since small movements of the members relative to each other will be prevented. The moment of inertia of the reinforced portion will then be that of the combined section rather than the sum of the moments of inertia of the separate members. When glue construction is used, the advisability of placing a small bolt near each end of the block should be considered. Spiking alone may be sufficient for long fills.



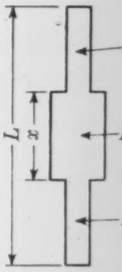
(*a*) (*b*)

FIG. 1. DEFORMATION OF SPACED TIMBER COLUMNS UNDER LOAD

The column with a central fill block can thus be likened to the column whose properties are given in Table I. The table has been prepared for use in conjunction with the familiar charts for solid columns. When the factor n given by the chart is multiplied by the length L, the product nL is the length of an equivalent column of moment of inertia I_1. The first lines of the chart indicate that when I_2 is very large compared to I_1, the effective length of the equivalent column is $L - X$.

TABLE 1. EQUIVALENT LENGTH OF A COLUMN WITH UNIFORM MOMENT OF INERTIA I_1

$\frac{I_1}{I_2} \diagdown \frac{X}{L}$	0	0.2	0.4	0.6	0.8	1.0
0	1.0	0.80	0.60	0.40	0.20	0.00
0.01	1.0	0.81	0.61	0.41	0.21	0.10
0.1	1.0	0.82	0.64	0.47	0.34	0.32
0.2	1.0	0.84	0.68	0.54	0.46	0.45
0.4	1.0	0.88	0.77	0.68	0.64	0.63
0.6	1.0	0.92	0.85	0.80	0.78	0.78
0.8	1.0	0.96	0.93	0.91	0.90	0.90
1.0	1.0	1.0	1.0	1.0	1.0	1.0



Example. A given column pin-ended, with $I_1/I_2 = 0.4$ and $X/L = 0.2$, would be equivalent to a uniform column of length equal to 0.88 L and moment of inertia equal to I_1. The value of n given by the chart may be used in the familiar Euler column formula thus,

$$P_{\text{critical}} = \frac{\pi^2 EI}{(nL)^2}$$

In any analysis of the effect of the end fill blocks in spaced columns, the slip in the joint must be considered. If adequate end fills are glued in place, they are similar to batten plates on spaced steel column members not having latticing, and may be analyzed in the familiar manner. However, the most common case in point in timber construction is that found in built-up struts acting as web members or chord members of wood trusses and frames. Here the end condition is usually a fastening of one or more bolts or pairs of split ring connectors (Fig. 2).

The bolts are usually placed in holes $^1/_{16}$ oversize and the recommended tolerance of the groove in split-ring connectors is 0.02 to 0.04 in. If the deflection is a sine curve, the slope α of the end of the column is $\pi e/L$.

A lateral deflection e in the strut equal to $L/300$, would correspond to a $^1/_{16}$-in. bolt movement at a distance from the center line of 3 in., such as would occur in a fill block 6 in. thick; or to 0.03-in. ring movements at a $1^1/_2$-in. distance from the center line, such as could occur with a fill block 3 in. thick under field conditions. If such tolerance exists and friction is neglected, these end conditions are of little value in stiffening the spaced column members.

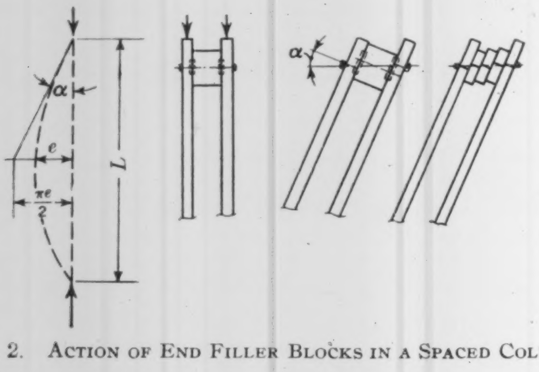


FIG. 2. ACTION OF END FILLER BLOCKS IN A SPACED COLUMN

The deflection e should include not only the initial bow in the column but also the increase of this bow by application of the end load and the effect of eccentric application of end loads, and other factors. Where the fill block is composed of a number of pieces—usually chord and web members—slip will occur on each of these planes.

Friction is seldom relied upon in joint design by conservative practice, and it appears that in design in timber it should not be considered because changes in moisture content inevitably tend to relieve bolt tension. A dimensional change of 1 per cent in two weeks is not infrequent. Repeated tightening of bolts does not prevent failures which occur the day before the bolts are tightened.

Tests of built-up columns with bolts tightened just before the test, and with loads applied through a head which keeps the tops of the column members in a single plane, give high values. Some failures have occurred when the end fill blocks have been assumed to greatly stiffen the members of the built-up column. A large amount of fixity is obtained in solid columns where square-cut ends bear upon parallel surfaces. In practice, irregularities may occur at the ends of the columns, and customary column formulas anticipate this condition.

The use of glued fill-blocks in built-up columns is recommended, especially at the ends, where shear stresses are high. In built-up columns fabricated without glue, long fill-blocks at mid-height will economically reduce the effective lengths of the slender column members.

Bending Moments in the Foundation Slabs of a Granary

By PAUL NEMENYI

ASSISTANT PROFESSOR OF MATHEMATICS, THE STATE COLLEGE OF WASHINGTON, PULLMAN, WASH.

IN the literature of bins and silos the question of the dimensions and reinforcement of a rectangular foundation slab supporting a number of silos is usually either left undiscussed or discussed in an unsatisfactory manner. The solution here presented is an approximate one, based on certain basic assumptions. These assumptions are:

1. The displacement of the soil surface under the slab is vertical and proportional to the vertical component of the pressure exerted by the slab at the same point.
2. The foundation slab is, compared with the soil under it, so stiff that it can be considered as a rigid rather than an elastic body.
3. The bending moment in each main direction can be computed as if in the other direction the slab was infinitely long. Thus the one-dimensional theory of beams is applicable instead of the elaborate two-dimensional theory of elastic plates or slabs.

For a given uniform live load extending to $\beta L/2$ on both sides from the middle, these assumptions lead to a moment diagram of a shape shown in Fig. 1 (a). Here L is the width of the slab, w the unit live load, and β the ratio of the width of loaded area to width of slab. The bending moment in the middle is obviously

$$\frac{w\beta(1-\beta)L^2}{8}$$

the largest value of this is reached when $\beta = 1 - \beta = {}^1/_2$, in which case the maximum bending moment is $wL^2/32$.

Somewhat less obvious is the determination of the most dangerous load for an arbitrary cross section. Influence lines are the obvious tools for this purpose although they do not seem to have been applied, so far to this particular problem.

The influence diagram for the bending moment in any cross section of a rigid beam resting on elastic soil consists of two trapezoids joining each other at the cross section in question. That this must be so follows easily from the known kinematical generation of influence lines, or from the more general principle established in *Eine Neue Singularitatenmethode für die Elastizitatstheorie*, by the writer (Zeitschrift f. Angewandte Mathematik und Mechanik, 1929), according to which any influence line can be represented as a deflection line for a suitably chosen force-singularity, the force-singularity corresponding to a bending moment being a system of three infinitely close forces forming a system of equilibrium.

Either of these principles yields, in addition to the general form of the influence line, also its three characteristic ordinates. These ordinates can be found, however, even more simply by placing the traveling unit load in the three characteristic positions and computing for each, first the linear soil pressure distribution, and from this the bending moment. In Fig. 1 (b) an example of these influence lines is represented and the three characteristic ordinates are given in terms of α, the dimensionless coordinate of the studied cross section.

Such an influence line has the important property that its total positive area has the same absolute value as its total negative area. This must be so because, if the slab is loaded uniformly over its total length, the live load bending moment becomes zero in any cross section, and therefore the positive and negative areas of any influence surface must compensate each other.

An elementary computation shows that this common maximum moment is represented by the function

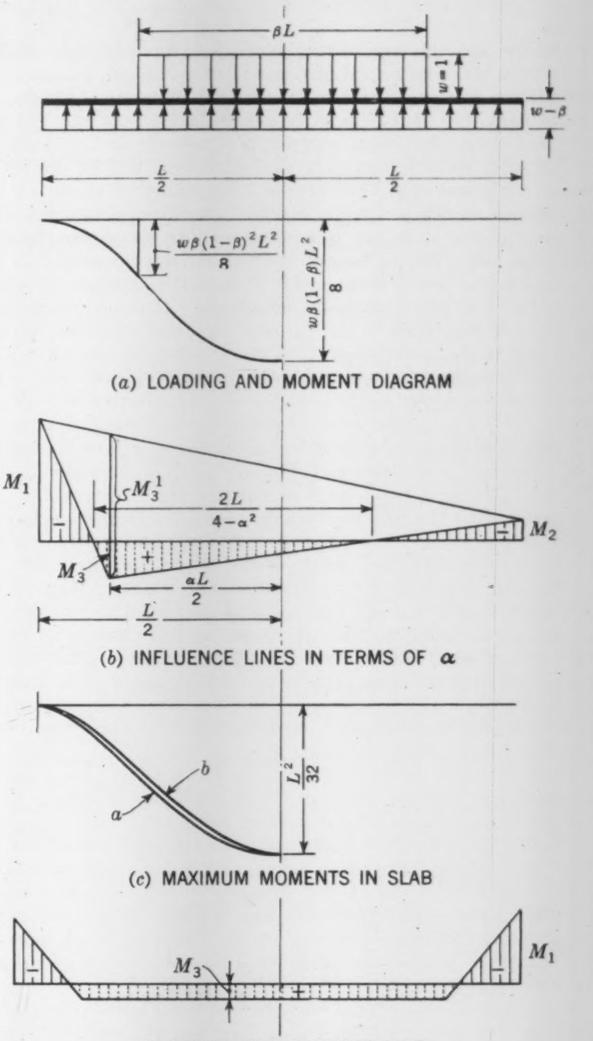
$$\pm \frac{L^2(1 - \alpha^2)^2 w}{8(4 - \alpha^2)}$$

in which L is the length, w the live load per unit length. In Fig. 1 (*c*), line *a* represents this function for the left-hand half of the slab.

However, as Dr. Clement C. Williams suggests (*The Design of Masonry Structures and Foundations*, 1st edition, New York, 1922), if the granary is operated in such a manner that two rows of bins, which are located symmetrically with respect to the middle, are always being filled, or emptied, simultaneously (a rule which may represent a useful precaution against possible one-sided settling of the structure), the maximum bending moments will be somewhat smaller than those given by the previously computed function. In order to compute this reduced bending moment, an influence line is needed which gives the joint bending moment resulting in the cross section α, from two unit loads moving in such a manner that they remain always in a symmetrical position as to the mid-point of the structure. Obviously such a combined influence line is obtained as the arithmetic mean of the ordinary influence lines for the cross sections α and $-\alpha$. In Fig. 1 (*d*) such a combined influence line, for the cross sections α and $-\alpha$, is represented. Its positive, or negative, area gives the respective positive, or negative, bending moment as a function of α. This is found to be

$$\pm \frac{L^2(1 - \alpha^2)^2}{32}$$

In Fig. 1 (*c*) this function is represented by line *b*. A comparison between the two curves shows that the difference between them grows from zero at the middle, to 25% at the ends of the slab. Since, however, toward the ends the moments are extremely small, the difference between the two curves has little or no practical significance. The mentioned rule of filling and emptying the silos symmetrically is therefore hardly justified as a means of securing economy in the reinforcement of the foundation slab—whatever advantages it may have otherwise.



βL
$w = 1$
$w - \beta$
$\frac{L}{2}$
$\frac{L}{2}$
$\frac{w\beta(1-\beta)^2L^2}{8}$
$\frac{w\beta(1-\beta)L^2}{8}$
(*a*) LOADING AND MOMENT DIAGRAM
M_1
M_3^1
$\frac{2L}{4-\alpha^2}$
M_2
M_3
+
$\frac{\alpha L}{2}$
$\frac{L}{2}$
(*b*) INFLUENCE LINES IN TERMS OF α
b
a
$\frac{L^2}{32}$
(*c*) MAXIMUM MOMENTS IN SLAB
M_3
+
M_1
(*d*) COMBINED INFLUENCE LINE

FIG. 1. FOUNDATION SLAB OF A PARTIALLY LOADED GRANARY
Bending Moments, Influence Lines, Maximum Bending Moments

Our Readers Say—

In Comment on Papers, Society Affairs, and Related Professional Interests

Postwar Planning and the Engineering Profession

Dear Sir: The theme of present-day thinking is postwar planning. This is at present one of the major concerns of industry and is a material issue with labor. There is nothing essentially wrong with this thinking. In fact, it is entirely pertinent that considerable thought be given to postwar planning. However, nothing must slow down the winning of the war. We must hasten this "postwar" period we plan for. And this planning should give serious thought to the people who are to conduct, and work with, industry in the postwar years. These people will, of course, be in every conceivable line of endeavor. While we're thinking so much about postwar planning, why not postwar planning for engineers?

All the men doing such an amazing job on the battle fronts are not engineers by profession. Many of them will never follow it as such after the war. Many of them have been educated in this work, but have had little practical experience. Some of these "military engineers" are such by training only, having had little, if any, technical education, or for that matter, advance education of any type. Some of them have had their educations interrupted. But by and large they are all picked for the job because of their ability to work and think as practical engineers—whether they be plain "G.I. Joe's" or commissioned officers. Whatever may have been their previous education and experience, they will be well grounded in the practical application of engineering principles. They will have learned to do things quickly, ingeniously, and under extreme difficulties. They haven't the time to prepare detailed, intricate drawings or to make complicated estimates. They have to apply engineering to unknown conditions without the opportunity to correct mistakes. They must be right the first time. In other words, these men practice engineering "the hard way." In addition to the field forces, there are those engineers in the Armed Services who have been coping with the tremendous problems of supply and construction on the home front. They have been fighting this war far from the sound of cannon, but they have had to overcome what sometimes seemed insurmountable technical and administrative obstacles. This sort of training must not be wasted.

Industry and the engineering profession have in these military engineers a hitherto unequaled source of technical, practical men who will be the postwar administrators, planners, foremen, and superintendents. But it must be remembered that many of these have had their educations stopped prematurely and, in their anxiety to enter more remunerative occupations, will be tempted to forego continuation of their studies. So many of them will have lost interest in education. Therefore, the first obligation of the American public in its postwar planning is to encourage those who have been taken from schools, or who have never entered an institution of higher learning, to pick up where they left off. To do this it may be necessary to subsidize education. However, nothing will pay greater dividends in the future. Postwar planning must not be limited to the years immediately following the war. Let's have enough vision and foresight to realize the dividends that will be paid to the employer, to the professional man, to the individual, by having personnel trained educationally to fulfill their missions.

There is no doubt that postwar possibilities will be tremendous; they must be—if the national economy is to be preserved. In no field will this be greater than in engineering. Specifically, I am concerned with the postwar engineer and his transition from the role of military engineer. The country must appreciate that it has for the asking engineers from every branch of the field—civil, mechanical, chemical, electrical, and all the others. Many of these men have simply started their professional lives in reverse; they have received their practical experience, some phases of it, ahead of their education. Others have simply augmented education and experience with the unusual opportunity to apply their science to practical military problems, requiring the use of sound judgment under extreme pressure and hardship and the ability to manage with few, if any, prepared tools.

These men will enter the employ of industry or "hang out their own shingles." They will want an opportunity to engage in their professions as a free-thinking, free-acting people.

It is vital that industry and the American public should not overlook this wealth. Spend it wisely. Thinking will be changed, methods will be modified and improved. The wartime engineer will exert a powerful influence in this respect. Many old methods and principles will be abandoned for their new ideas. Engineering, like all other professions and sciences, will advance and profit through the emergencies and hardships of war.

It is important that plans be made now to utilize our engineers to the fullest extent. No cut-and-dried plan will suffice. It is not enough to say that the soldier, as a former employee now engaged in military work, will have a job upon his return. The profession must remain open minded and expect to learn from these men and to utilize their vast experience. Think it over!

HERBERT P. WINN, Assoc. M. Am. Soc. C.E.
Major, Corps of Engineers, U.S. Army

Pittsburgh, Pa.

Comments on Air Transport in Latin-America

DEAR SIR: In the May issue the article by J. Stanton Robbins gives me great concern. One gathers from it that air transport is replacing all other forms of transport in Latin-America—an impression which, if created, is I believe erroneous.

That our air transport has made great advances in the last 25 years is, of course, a truism. That American highways are also important is testified to by Commissioner MacDonald in the same CIVIL ENGINEERING. South and Central America, it is true, are different from North America, but it is also true that for all three, railways and highways are still, and are likely to remain, the mainstay of commercial transportation.

In discussing Latin-America there is a tendency to lose perspective. In 1938 I flew from Venezuela to New York in 26 hours. The first time I made the same journey going south it took three weeks by steamer. Just as soon, however, as the Grace Line operates passenger ships again, I shall go by steamer from New York to La Guayra, though it takes five days. I expect I shall have lots of company. During this past winter when I was in Caracas, newspapers from New York, sent by regular mail, took 4 to 5 weeks, airmail 7 to 10 days.

What does one infer from this? As a matter of fact, none of these citations is of much value in estimating the future of transport between the United States and the southern Caribbean. May one argue from these facts that the airplane is to replace steamer service? I think not. No one denies that it may take a few hours to go by plane from Lima to Iquitos; that it may take two or three weeks by trails over the Andes, or by steamer around the coast. But who wants to go? A few passengers perhaps, maybe a few troops—certainly no freight or merchandise that has any economic value. This instance is perhaps typical of those Mr. Robbins cites.

I question, also, the statement that the plane goes today to many places where the people have never even seen a truck. Trucks, buses, and automobiles are to be found almost everywhere in Latin-America as here, and I would venture the guess, based on personal experience, that 90% of the people of Latin-America, certainly 90% of those who count, have seen a railway. Almost all the places where airplanes can land have been graded by modern machinery.

The emphasis in the title that the "Trade Centers" that trade with each other are "linked together by air" is to say the least misleading. The fact that many places prominent in commerce are so linked is of no more importance than that Boston, Atlanta, Chicago, San Francisco, and so on, are linked together by air transport. The trade and production centers that count in Latin-America have to have access to the ocean and so to North America, the Orient, and Europe by sea, and this access they have had and still have by rail and highway. The airplane has not changed this.

I do not wish to be misunderstood as belittling air-transport developments. The airplane has been of great advantage, but there is no development in sight that even indicates it will take the place of highways, railways, or steamships in carrying on the vital commerce and trade of the world.

That the development of air transport means "The American republics are on the threshold of their greatest evolution," as Mr. Robbins says in his opening sentence, ignores a great many factors of importance.

FRED LAVIS, M. Am. Soc. C.E.
Consulting Engineer

New York, N.Y.

Forum on Professional Relations

CONDUCTED COLUMN OF HYPOTHETICAL QUESTIONS WITH ANSWERS BY DR. MEAD

In the current issue Dr. Mead gives his answer to Question No. 25, which was given in the August issue of "Civil Engineering." The question reads as follows: "A municipality hires the services of an engineer on a salary basis of $3,000 per year. Is the engineer justified in doing private work during his spare time and keeping the pay therefor for his own private use?"

Like most questions on ethics, this question is not sufficiently complete in itself to be answered definitely. When a man is employed for service by a municipality or by others, there should be a definite understanding as to whether he is to devote his entire time to the business of his employer or whether he is at liberty when his employer's work is completed to do outside work. If his entire time is entailed by his employment he should certainly not attempt private work on the side; but such work may be entirely legitimate if it is understood to be so at the time of his employment.

DANIEL W. MEAD, Past-President and
Hon. M. Am. Soc. C.E.

Madison, Wis.

Question No. 26, which was announced in the September issue, will be answered in the forthcoming, or November, number. Next in the series the following question is announced. Replies may be received until November 5, with answers in the December issue.

QUESTION NO. 27: *An engineering student who expected to graduate in June received in March an offer for a position from Company A. This he immediately accepted with the understanding that he was to begin work on July 1. In May, the student received from Company B an offer which he liked much better and which he thought offered a better chance for advancement. The student had signed no formal contract with Company A. What should he do?*

SOCIETY AFFAIRS

Official and Semi-Official

Two Bills Authorize Postwar Construction Funds

Funds for the planning and construction of postwar public works have been authorized by two bills recently passed. On September 20 the House passed the so-called "Demobilization Bill," providing among other things for the extension of loans to public agencies for the making of plans for postwar work. This bill will become law when signed by the President. The second bill is the Federal Aid Highway Bill, S2105, passed by the Senate on September 15, authorizing a total of $1,350,000,000 for highway construction.

The funds authorized by the Highway Bill are proposed to be allocated at the rate of $450,000,000 a year. Participation by the states would be on a fifty-fifty basis. Railroad companies would be required to bear 15% of the cost for construction of grade crossings. This bill then went to the House for final disposition.

Postwar planning funds authorized by HR1902, the "demobilization bill," will be administered by the Federal Works Administration. The section of the bill (Sec. 501) which deals with these funds, closely compares with the proposal which representatives of the Society's Committee on Postwar Construction made to the Lanham Committee in January (see Civil Engineering for March 1944, p. 127). Although this bill authorizes the loan of funds, no appropriation for such purpose is included. If such funds are made available, they are to be distributed in proportion to the populations of the various states.

An excerpt from S2051 (HR1902), "To Provide a National Program for War Mobilization and Postwar Adjustment," passed by the Senate August 10, 1944, and immediately referred to the House Ways and Means Committee, follows:

"Sec. 502 (*a*) In order to encourage States and other non-Federal public agencies to make advance provision for the construction of public works (not including housing), the Federal Works Administrator is hereby authorized to make, from funds appropriated for that purpose, loans or advances to the States and their agencies and political subdivisions (hereinafter referred to as 'public agencies') to aid in financing the cost of architectural, engineering, and economic investigations and studies, surveys, designs, plans, working drawings, specifications, procedures, and other action preliminary to the construction of such public works: Provided, that the making of loans or advances hereunder shall not in any way commit the Congress to appropriate funds to undertake any project so planned.

"(*b*) Funds appropriated for the making of loans or advances hereunder shall be allotted by the Federal Works Administrator among the several states in the following proportion: 90 percent in the proportion which the population of each State bears to the total population of all the States, as shown by the latest available Federal census, and 10 percent according to his discretion: Provided, that the allotments to any State shall aggregate not less than one-half of 1 percent of the total funds available for allotment hereunder: Provided further, that no loans or advances shall be made with respect to any individual project unless it conforms to an over-all local or regional plan approved by competent local or regional authority.

"(*c*) Advances under this section to any public agency shall be repaid by such agency if and when the construction of the public works so planned is undertaken. Any sums so repaid shall be covered into the Treasury as miscellaneous receipts.

"(*d*) The Federal Works Administrator is authorized to prescribe rules and regulations to carry out the purposes of this section.

"(*e*) As used in this section, the term 'State' shall include the District of Columbia."

Membership in Society Passes 20,000 Mark

Official records of membership in the Society, as printed on page 14 (back section) of this issue, indicate a total now well over the 20,000 mark. Adding to this number the members of Student Chapters throughout the country, nearly 23,000 men are now affiliated with the American Society of Civil Engineers.

As is indicated in Fig. 1, most rapid growth is shown by the Juniors. In the twelve-month period ending September 9, over 600 Juniors have been added to the membership. In the same period 252 persons have achieved full Member grade and 441 have become Associate Members.

Members of the Student Chapters are not strictly members of the Society. This record is added to the chart merely to signify the number which can be considered an active part of this sphere of professional interest. The drop in the number during the past two years can be readily correlated with the drop in college enrollment of male students.

Actually the assumption that the Society now has over 20,000 dues-paying members is in error. Nearly 1,000 men now in the armed forces have been exempted from payment of dues by action of the Board (see Civil Engineering for August 1944, p. 367). Another group of members reside in countries with which communications have been interrupted by the war so that, even though they are still carried as members, they cannot be expected to maintain their Society contacts.

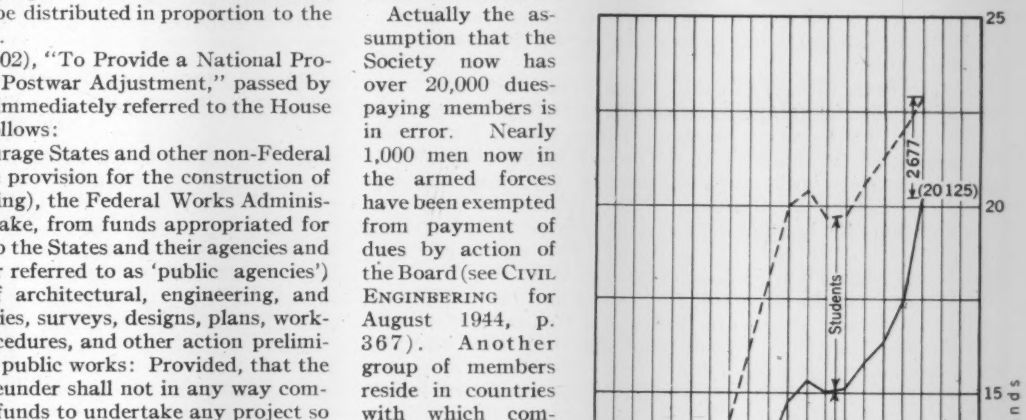
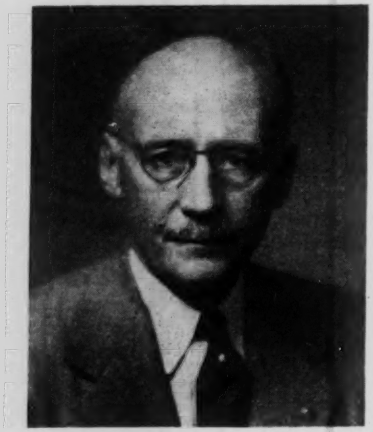


Fig. 1. Graph of Society Membership Since 1852

Society Retains New Field Secretary

ON AUGUST 17, Henry L. Thackwell, M. Am. Soc. C.E., of Pasadena, Calif., joined the Society's staff as Field Secretary assigned to the area consisting of the 11 Western States and Texas. He will be a staff member, representative in that area of the Society in all its aspects and operations.

Mr. Thackwell will assume those duties formerly handled, as best might be, by visits of staff members whose headquarters were in New York City. It is not planned, however, that his presence shall be in any way a substitute for such visits to the western members as may be practicable by successive Presidents of the Society, or by the Vice-Presidents or the Directors in that area.



HENRY L. THACKWELL
M. AM. SOC. C.E.

He will be of assistance to the Local Sections and Student Chapters in the area now assigned to him, and will be available to give guidance to those groups of Professional Engineering Employees that may be in need of information on matters pertaining to employment conditions. In short, his duties will be to serve in any way in which a staff member can be of use to the membership—to locate publishable material of professional interest, to contribute what he can toward the activities of the administrative and professional committees of the Society, to fulfill an educational and informative function, and in general to look out for the interests of the Society in this area.

He brings to the Society a wealth of experience dating back to the exploratory work for the construction of the Detroit River tunnel in 1908. In 1909 he was in Shoshone, Idaho, for the J. G. White Company, and from that time to the present he has been actively engaged on engineering projects in Colorado, Wyoming, Washington, British Columbia, Nicaragua, Chile, Texas, and California. For many years his headquarters were in Denver, later in Dallas, and San Antonio. He comes to the Society from Pasadena, Calif., where he has been in independent private practice.

In 1912 Mr. Thackwell entered the Society as a Junior. He was elected an Associate Member in 1916, and a Member in 1936. He spent the latter part of August at Headquarters in New York, becoming acquainted with the many details of procedure in connection with Society activities. It is planned that he will attend the meeting of the Board of Direction which is to be held in Denver October 9 and 10. After that Mr. Thackwell will return to the Coast to pursue his new duties. For the present his headquarters are in Pasadena, Calif., and he can be reached through P. O. Box 257, by telephone at Pasadena Sy 2-9122, or at his home, 126 South Marengo Avenue, Pasadena 17.

Delay of 1944 Transactions

THE TRANSACTIONS of the Society, normally issued in October, will doubtless be held up several months unless miracles of supply and production can be worked. Although paper was ordered months ago for this year's volume, it has been impossible for the mills to make delivery. The paper used for TRANSACTIONS is 57-lb Bible paper. The lack of supply of this and many other printing stocks is due to the inadequate assignment of pulp for such uses.

Well over 60,000 lb of paper will go into the 1944 TRANSACTIONS. This issue will contain 1,640 pages, and over 19,000 copies will be printed. Many important and interesting pape s printed during the year will be included, with their discussions and the authors' closing comments. Memoirs of deceased members will also appear in this volume.

Every effort will be made, as soon as paper is available, to complete the printing of TRANSACTIONS and get it into the hands of readers without further delay.

FWA Report Shows Small Volume of Completed Plans for Postwar Public Works

PLANS for less than one billion dollars worth of state and local public works, exclusive of a federal-aid and state highway projects are in the completed stage, according to a report prepared by the Federal Works Agency in collaboration with the Bureau of the Census for the Special Committee on Postwar Economic Policy and Planning of the House of Representatives. The report, submitted September 13 by Maj. Gen. Philip B. Fleming, Administrator, Federal Works Agency, is based on replies from 1,480 state and local governments, out of a total of 4,643 to which a uniform questionnaire was addressed just before the middle of July. Replies were accepted for use in the report until August 23.

Those replying include, in general, the governmental units most active in postwar public works planning. The questionnaire went to all states, to all counties, to all cities over 10,000 population, and to 10% of the cities in the 2,500–10,000 population range. All types of governmental units responded in good volume except non-metropolitan counties, 2,838 in number, which returned only 566 reports. Forty-four states reported, and 83 of 92 cities over 100,000 population filled out their questionnaires.

Results of the survey are summarized in the accompanying table, taken from the report. The questionnaire requested information on the status of public works plans in: (1) Completed Stage, (2) Design Stage, (3) Preliminary Stage, and (4) Idea Stage. These design designations coincide closely with those adopted by the Society's Committee on Postwar Construction in November 1943 and published in the December 1943 issue of CIVIL ENGINEERING. The report marks the culmination of a plan long encouraged by the Society's Committee. E. Lawrence Chandler, the Society's Washington Representative, worked actively with the Federal Works Agency in developing the program.

TABLE I. SUMMARY OF ESTIMATED COST AND FINANCIAL ARRANGEMENTS FOR PROPOSED POSTWAR PROJECTS FOR ALL GOVERNMENTAL UNITS REPORTING

(In Thousands of Dollars)

STAGE OF PLAN PREPARATION	NO. OF GOVERNMENTAL UNITS REPORTING PLANS	NO. OF PROJECTS	ESTIMATED TOTAL COST
I. Completed	600	6,559	$ 969,858
II. Design	655	7,920	1,749,242
III. Preliminary	740	14,791	3,701,884
IV. Idea	956	27,513	6,297,387

	STATUS OF FINANCIAL ARRANGEMENTS		
STAGE OF PLAN PREPARATION	Funds on Hand or Arranged for	Negotiations Under Way	Not on Hand, Arranged for or Under Negotiation
I. Completed	$304,680	$ 50,697	$ 614,481
II. Design	258,255	113,747	1,377,240
III. Preliminary	267,216	167,976	3,266,692
IV. Idea	345,034	199,272	5,753,081

Postwar construction plans for federal-aid and state highway projects, reported by the states to the Public Roads Administration, are summarized separately in the report. Totals for these projects are not included in the table reproduced here. As of July 1, 1944, there were 219.2 million dollars of highway projects in the completed state, 957.2 million in the design stage, and a little more than one billion dollars in the preliminary stage.

Close agreement with the FWA is indicated by the Society's reported volume of public works plans in the proposed and design stages. According to project reports supplied to the Society's Committee by the McGraw Hill Company, public works plans on September 1, 1944, amounted to 3.7 billion dollars in the design stage and 11.7 billion dollars in the proposed stage. Including privately financed projects, the gross totals for that date were 4.0 billion of plans under way or completed and 13.5 billion proposed. These totals represent increases of about 100% in both classifications during the five months since the Society's Committee set up a full-time staff to effect more active implementation of its postwar program.

Known volume of plans in the design stage for privately financed postwar construction on September 1, was only 282 million dollars, or about 1/28th of the amount it should be to maintain its proper relative position with public works. During recent weeks, both President Pirnie and the Committee have gone on record regarding the seriousness of the apparent lack of private postwar construction planning.

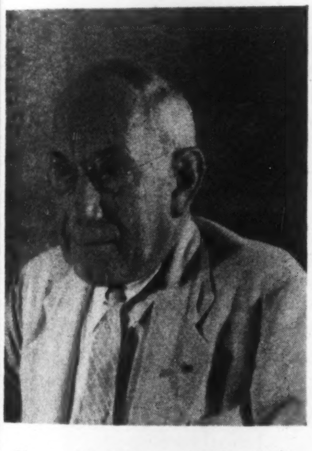
Death of Henry Matson Waite, Hon. M. Am. Soc. C.E.

Members of the Society will be grieved to hear of the death of Henry Matson Waite, Hon. M. Am. Soc. C.E., which took place in Washington, D.C., on September 1, 1944. Colonel Waite, who was 75, was long prominent in engineering circles. During 1933 and 1934 he served as Deputy Administrator of the Public Works Administration and, at the time of his death, was a consultant on war projects in the U.S. Bureau of the Budget.

He was born and reared in Ohio, and much of his later important engineering work was done there. Following his studies at the Massachusetts Institute of Technology, he spent twenty years in railroad work, distributed between Ohio and Florida. Then for a period he was vice-president and chief engineer of the Clinchfield Coal Corporation at Dante, Va., resigning in 1912 to become chief engineer for the City of Cincinnati. From 1914 to 1917 he was city manager of Dayton, Ohio, leaving this post to serve in the first World War. His tenure as city manager was interesting and difficult because of problems arising from severe floods in the Miami Valley.

During the war he had the rank of colonel in the Corps of Engineers, U.S. Army, and was assigned to the Transportation Corps of the A.E.F. In recognition of his services as deputy director general of transportation in the A.E.F., he was awarded the Distinguished Service Medal by the United States and was made an officer of the Legion of Honor of France.

For several years following the war he was in private consulting practice in New York. Then (in 1927) he became chief engineer of the Cincinnati Union Terminal Company on the development and construction of its great objective. This project—bringing together the various roads entering Cincinnati in one great center with yards attached—proved to be one of the most important contributions of Colonel Waite's career.



Henry M. Waite, 1869–1944

After the completion of the terminal in 1933 Colonel Waite was largely in government service. In addition to his work as Deputy Administrator of the PWA, he was technical adviser to the National Resources Board and the National Youth Administration and, since 1940, had been consultant to the Bureau of the Budget. In the meantime, for part of this period, he was also chairman of the Chicago Subway Committee.

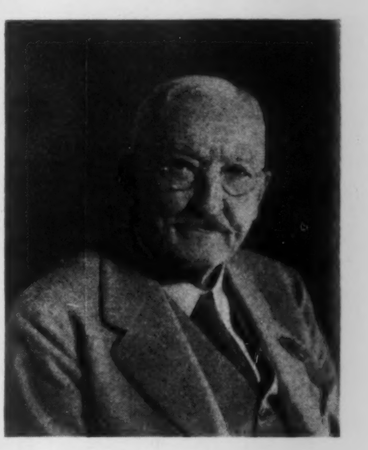
A member of the Society since 1914, Colonel Waite served a term as Vice-President in 1931 and 1932. He was elected Honorary Member in 1941.

Publicity for Postwar Program

Millions of Americans have been reading of the activities of the Society's Committee on Postwar Construction. Newspapers in many cities have been carrying dispatches released by the Committee's Research and Development Division, through the Associated Press, United Press, and International News Service. Clipping bureau returns indicate that nearly 40 newspapers with a combined circulation of nearly 5 million have been publishing the planning figures accumulated by the Division.

Mortimer E. Cooley, Honorary Member, Dies

After a long and distinguished career in the practice of civil engineering and as an engineering teacher, Mortimer E. Cooley, Hon. M. Am. Soc. C.E., died in Ann Arbor, Mich., on August 25. Although Dean Cooley had been seriously ill for over a year, he remained mentally alert. In fact, he had quite recently worked on his autobiography, "Scientific Blacksmith: Sixty Years an Engineer," which is now in the hands of the publisher.



Mortimer E. Cooley, 1855–1944

Born in Canandaigua, N.Y., on March 25, 1855, Dean Cooley received his education at the U.S. Naval Academy at Annapolis, graduating in 1878. In August 1881, following the customary tour of sea duty, the young ensign was assigned to the University of Michigan to inaugurate a course in mechanical engineering. Thus began an active teaching career of half a century. In 1904 he was placed in charge of all engineering work at the university, and so was affectionately known as "Dean Cooley" to thousands of students and engineering alumni. Since 1928 he had been retired, with the rank of dean emeritus of the college of engineering and architecture.

In 1900 Dean Cooley undertook the Michigan Railroad Valuation, which included investigation of the 10,000 miles of Michigan railways, and later served in a similar capacity for Wisconsin and Newfoundland railways. He was also in charge of special investigations of public utility properties in numerous cities of the United States.

Dean Cooley's strong sense of public duty led him to consent to act as Michigan State Engineer under the Federal Public Works Administration in 1933 and 1934, and as director in 1935. He was, also, president of the Advisory Council of the Ann Arbor Joint Commission on Public Service. One of Dean Cooley's strong interests was engineering education—he laid great stress on the need of a broad foundation for technical studies—and he was the author of numerous works on the subject.

He had been honored by many engineering societies, including the American Society of Mechanical Engineers, of which he was past-president and honorary member. Long a member of the American Society of Civil Engineers, he served as Director from 1913 to 1916, and was elected an Honorary Member in 1935.

News of Local Sections

Scheduled Meetings

Cleveland Section—Dinner meeting at the Cleveland Engineering Society on October 20, at 6:30 p.m.

Colorado Section—Host during the week of October 8 to the officers, Board of Direction, and national committees of the American Society of Civil Engineers, and to the delegates from fifteen Sections at a Regional Local Section Conference.

Dayton Section—Luncheon meeting at the Engineers Club on October 16, at 12:15 p.m.

Ithaca Section—Dinner meeting at the Alhambra Hotel on October 19, at 6:30 p.m.

Los Angeles Section—Dinner meeting at the University Club on October 11, at 6:45 p.m.

Maryland Section—Dinner meeting at the Engineers Club on October 26, at 5:45 p.m.

METROPOLITAN SECTION—Technical meeting in the Engineering Societies' Building on October 18, at 8 p.m.

MIAMI SECTION—Vacation meeting on October 5, at 7 p.m. (Place to be announced later.)

NEW MEXICO SECTION—Lecture by Wesley R. Nelson, Director, Region No. 5, U.S. Bureau of Reclamation, at Harvey Junior High School on October 19, at 7:30 p.m.

NORTHWESTERN SECTION—Meeting on October 2, at 6:30 p.m. (Place to be announced later.)

PHILADELPHIA SECTION—Meeting at the Engineers' Club on October 10, at 7:30 p.m.

SACRAMENTO SECTION—Regular luncheon meetings at the Elks Club every Tuesday at 12 m.

SEATTLE SECTION—Dinner meeting at the Faculty Club on October 2, at 6:30 p.m.

TENNESSEE VALLEY SECTION—Joint session of the Chattanooga Sub-Section with the American Society of Mechanical Engineers in the Power Building on October 10, at 6 p.m.; dinner meeting of the Knoxville Sub-Section at the S. & W. Cafeteria on October 11, at 6:30 p.m.

TEXAS SECTION—Regular luncheon meetings of the Dallas Branch at the Adolphus Hotel on the first Monday of each month at 12:15 p.m. Regular luncheon meetings of the Fort Worth Branch at the Blackstone Hotel on the second Monday of each month at 12:15 p.m.

TRI-CITY SECTION—Dinner meeting at the LeClaire Hotel on October 12, at 6:30 p.m.

Recent Activities

KANSAS CITY SECTION

On June 23 members of the Kansas City Section met at the Mission Hills Country Club for a dinner and technical program. During dinner William Ganz entertained with piano music, and later in the evening there was group singing led by James Fern. The speaker of the evening was Prof. Gus W. Dyer, of Vanderbilt University, who discussed certain aspects of postwar planning. Guests of honor included Past-President E. B. Black, former Director E. E. Howard, and Senator James Reed.

LOUISIANA SECTION

The Louisiana Section held two meetings in July. On the 14th the group enjoyed a combined luncheon, technical session, and inspection trip aboard the Dock Board yacht, "Hugh McCloskey." Departing from the foot of Canal Street (New Orleans) at noon, the yacht proceeded through the Industrial Canal to the new Intercoastal Canal, and into the Intercoastal Canal to the Higgins Aircraft Plant. Following luncheon and a business meeting, Franklin Thomas spoke on the rôle of the Society in collective bargaining and postwar planning. Professor Thomas is Vice-President of the Society. The regular meeting, on the 17th, was held jointly with the Louisiana Engineering Society. On this occasion the technical program consisted of a talk by Col. W. N. Carey, chief engineer for the Federal Works Agency, whose subject was "Plan Jobs or Relief Program—Which?" Colonel Carey's statement that Louisiana had only $25,000 of planned work led to considerable discussion from the floor.

MARYLAND SECTION

At the suggestion of the chairman of the publicity committee of the Section, the County Commissioners Association of the Western Shore devoted its August 2d meeting largely to postwar planning. The Association is composed of representatives of the fourteen counties in Maryland lying west of the Chesapeake Bay. Mr. Pasarew, director of the Maryland State Planning Commission and of the Postwar Reconstruction and Development Commission, explained in detail a manual, which has been prepared under the direction of Dr. Abel Wolman, chairman of the State Planning Commission. The manual discusses the essential features of the mechanics of postwar planning and contains a plea to "blueprint" now. The president of the Maryland Section, Paul L. Holland, then gave a short talk on the status of postwar planning, emphasizing the responsibility of planning officials in providing for economically feasible construction projects and the concomitant employment.

MID-SOUTH SECTION

The summer meeting of the Mid-South Section took the form of an all-day session, held in Memphis, Tenn., on July 26. Guests included two Directors of the Society—Dean N. W. Dougherty and W. D. Dickinson—and former Director Robert B. Brooks. During the morning technical session Marion L. Crist, consulting engineer of Little Rock, Ark., presented a paper on postwar construction. He was followed by Charles Senour, head engineer for the Mississippi River Commission, whose subject was the new project for stabilizing and deepening the Lower Mississippi River. The remainder of the morning was devoted to the presentation of committee reports. Luncheon was served at the Officers Club of the Memphis Army Service Forces Depot. Col. Harold E. Schlesinger welcomed the group, and W. F. Schulz spoke on the design and construction of the Depot plant. The next speaker was Lt. Col. Leo H. McKinnon, who described the establishment and operation of the first general depot in North Africa. An inspection tour of the Depot—conducted under the supervision of Colonel Schlesinger, Deputy Depot Commander—concluded the technical program.

OKLAHOMA SECTION

Members of the Oklahoma Section held a meeting in Oklahoma City on July 15. In the afternoon there was a business session, followed by the presentation of a paper on "The Use of the Reynolds' Number in Hydraulic Calculations." This was given by Edward R. Stapley, acting dean of engineering at Oklahoma Agricultural and Mechanical College. The principal speaker scheduled for the evening technical program was Edward C. Burris, assistant dean of commerce at the college. His subject was "Methods of Community Analysis for Industrial and Agricultural Development." During the evening it was announced that the Section's prize of Junior membership in the Society for the most outstanding civil engineering graduate had been awarded to Fulton K. Fears.

OREGON SECTION

A symposium on the "Preliminary Investigations for the Portland Sewerage Project" was the feature of the June meeting of the Oregon Section. Those taking part were Ben S. Morrow, city engineer, and J. W. Cunningham and R. E. Koon, local consultants. Mr. Morrow discussed the history of the development of the project and the city's interest in sewage problems. Mr. Cunningham then followed with a talk on the overall problems connected with the project, and Mr. Koon concluded the symposium with a detailed discussion of the specific problems encountered in laying it out.

SACRAMENTO SECTION

At the first of five August meetings R. W. E. Caruthers, of the General Electric Company, exhibited a late-model turbo-supercharger and spoke on the history and recent inventions in the field of gas turbines. On August 15 Wilson L. Davis, member of the Section, gave a running comment to motion pictures of the construction of the Tonopah Army Air Base in the face of unusual difficulties in the way of wind, dust, and heat. At the next meeting Anatole A. Eremin, in the light of his engineering experiences in Harbin, Vladivostock, and Shanghai, voiced his opinion of the peace problems in the Far East. On the 29th Attorney Henry Holsinger, of the California State Department of Public Works, reviewed the history of water law in the Western states and briefed new legal theories by which federal agencies seek to wrest control of unused water from the states.

SAN FRANCISCO SECTION

A talk on the U.S. Bureau of Reclamation's program for the Central Valley Project constituted the technical program at the regular bimonthly meeting of the Section, which took place on August 15. This was given by Charles E. Carey, regional director for the Bureau, who touched upon the historical background of the project and the issues involved. Projected plans include development of natural and water resources in the Sacramento and San Joaquin valleys of California; transportation of runoff from the Sacramento to the San Joaquin Valley to serve irrigation needs; expansion of hydroelectric power development; and conservation of all water so that it may be put to beneficial use. Following Mr. Carey's address, another member of the staff of the Bureau showed moving pictures of the construction of Shasta, Keswick, and Friant dams and the relocation of the Southern Pacific Railroad around Shasta reservoir.

Student Chapter Annual Reports

Abstracts of Reports as Provided by the Society's Committee on Student Chapters. These Reports Cover Roughly the Period from June 1942 to December 31, 1943, Because of the Change in the Student Chapter Fiscal Year. Other Abstracts Will Appear in Later Issues

Editor's Note: Because of abnormal conditions caused by the war the Student Chapter annual reports have been slow in coming in. Though many Chapters have remained active despite wartime problems and conditions, others have been forced to curtail their activities drastically and some (23) to assume an inactive status for the duration. For this reason there are fewer reports than in past years.

ALABAMA POLYTECHNIC INSTITUTE

The past school year has been a most successful one for the Chapter. The spirit and enthusiasm of the members have been at a peak. Several members were lost to the Armed Forces, but a number were returned to the school under the Army program. A variety of meetings were enjoyed throughout the year with the cooperation of the faculty, students, and interested friends. The Chapter was well represented at the District meeting in Birmingham on April 9, and at the annual meeting of the Alabama Section in Montgomery on December 10 and 11. The spirit of the members was shown in the interesting exhibits they prepared for the annual Engineers' Day, sponsored by the Auburn Engineers' Council to foster appreciation of the School of Engineering.

MANHATTAN COLLEGE

We members of the Manhattan College Student Chapter are proud of our record from October 1942 to December 1943. During this period we have had 17 regular monthly and business meetings, most of them attended by prominent guest speakers. We feel that our pride is justified on the basis of the activities in which we have participated, and of the work that we have performed on behalf of the Society. Our activities have been reported by the college administration and the faculty as a stabilizing force on the campus in the face of constant changes resulting from the war. We have been asked to convey to the Society the gratitude of the college for encouraging our activities.

GEORGE WASHINGTON UNIVERSITY

This is the Chapter's second "war report," covering the period from July 1, 1942, to December 31, 1943. Naturally the war has greatly influenced the activities of the members of this Chapter, as most of them are full-time employees of various governmental agencies in Washington, and find it extremely difficult even to continue class attendance. Inspection trips have been entirely abandoned due to lack of time and transportation facilities and to the confidential nature of the work being done in neighboring industries.

On the other side of the picture, the war has increased the importance of engineering and the study of it. Consequently, the Chapter has been able to maintain a working nucleus of members to carry out its functions and aims. The decrease in membership is slight and not considered excessive under the circumstances. The Chapter is also represented in the Engineers' Council, a general executive and coordinating body for all student engineering activities. Several members have been active in, and officers of, various national professional and honorary engineering fraternities. The present Chapter personnel intends to make every effort to maintain an active working organization.

BUCKNELL UNIVERSITY

During the past school year the Bucknell University Student Chapter has functioned under difficulties. Four different students served as president, all but a mere handful of the civil engineering students left for military duty, six hundred strangers moved to the campus and, as a step to prevent disintegration, the Chapter joined in the activities of the three other societies represented at Bucknell. It was a difficult period, indeed, but the Chapter succeeded in weathering the storm and, at the close of the period, there were signs of good things to come.

UNIVERSITY OF CONNECTICUT

Under the accelerated course prescribed for the University of Connecticut engineering school, the 1943–1944 academic year started in June 1943 and terminated in February 1944. Although there was a great reduction in membership during this period, the Student Chapter continued its activities as an engineering organization. High lights of the year included a civil engineering display at the Engineers' Ball; field trips to the Willimantic water supply, the Hartford sewerage disposal plant, and the Hartford flood control project; attendance at the 1944 Annual Meeting in New York; and student presentation of technical papers at Chapter meetings.

COOPER UNION

The third period of Chapter activities at Cooper Union started rather precariously. Three seniors, five juniors, six sophomores, and no night students (the night school suspended classes during the summer) were all that remained. The only semblance of an officer left to the Chapter was a previous delegate to the Metropolitan Conference. Complicating matters further was the graduation of the seniors in August 1943, and the uncertain draft status of many of the sophomores and juniors. Despite these problems, it was decided to carry on the summer activities without election of officers. Some day men helped, and Seymour Zubkoff assumed the duties of acting secretary.

NEW YORK UNIVERSITY

Members of the New York University Chapter have a number of interesting prizes open to them. They are eligible for the Robert Ridgway Prize of Junior membership in the Society, given by the Metropolitan Section, and the Arthur S. Tuttle Prize of $25, established by a group of engineers in honor of Arthur S. Tuttle, an alumnus of the engineering school at New York University. Also, the civil engineering faculty awards a handbook each year for the best Student Chapter paper presented in the senior seminar course. In the spring of 1943 the Chapter was host to the Metropolitan Conference of Student Chapters.

VIRGINIA MILITARY INSTITUTE

The Chapter at Virginia Military Institute has been in operation for twenty-two years. At the beginning of the 1942–1943 school year our Chapter had the largest enrolment in its history. The policy of allowing student speakers to choose their own topics was announced by the newly elected officers. Fifteen such speakers were scheduled during the year. By going on trips and attending meetings, we have followed as nearly as possible the aims of the Society in promoting an interest in civil engineering and maintaining the high ideals of the profession.

CADETS TRAINING AT VIRGINIA MILITARY INSTITUTE

From September 1942 until early in 1943 our Chapter proceeded almost as in normal years except for the absence of visiting alumni. However by May, we had lost, through graduation or induction into the services, almost the whole of our Chapter personnel. In spite of such unsettled conditions there was no lack of interest in either the meetings or programs. Due to curtailment of travel we have had few outside speakers for our meetings. For the duration we shall do our best to continue our Chapter with the means and opportunity at hand.

WEST VIRGINIA UNIVERSITY

During the period covered by this report (mid-year of 1942 to December 31, 1943) 42 meetings were held. These included a special general engineering society meeting once each month, at which time all members of the four engineering societies convene to conduct their business and to enjoy a program presented by one of the joint societies. Active participation in the affairs of the Student Chapter is indicated by the fact that 112 papers were presented by the 21 members. Since the spring of 1943 inspection trips have been discontinued for the duration. Prior to that time we were able to undertake two trips, visiting the water plants at Fairmont, Clarksburg, Grafton, Tibbs Run, and Morgantown. The annual summer survey camp, which all Chapter members attend, was not held in 1943 because of the accelerated program.

STUDENT CHAPTER GROUP AT WEST VIRGINIA UNIVERSITY

On July 23 student members and the civil engineering faculty motored to Professor Down's summer cottage overlooking beautiful Lake Lynn. There were games and swimming, and supper was cooked outdoors. Not in a long time had students and faculty had such a happy get-together.

LAFAYETTE COLLEGE

During the past year the Chapter at Lafayette College has had a meeting approximately every month, although not at regular intervals. It has been difficult to run the Chapter as in other years because of the constant withdrawal of students from college to enter the Armed Forces. Also, the new accelerated college program made the adequate preparation of student talks difficult because of interference with regular college work. On the whole, however, the Chapter's activities were conducted in a business-like manner and justified the existence of the Chapter by adding to our knowledge of civil engineering. In December we lost by graduation all but one of our active members, so it was decided to apply for inactive status until it is feasible to resume activities.

UNIVERSITY OF ALABAMA

The University of Alabama Student Chapter has had a busy and industrious year in spite of the war situation. Throughout the year the members and faculty were interested in the development and activities of the Chapter. Several interesting meetings were held, featured by movies of the Tacoma Bridge failure, and several talks prepared by Chapter members on malaria control and other timely topics. Through the courtesy of the State Highway Department we were able to inspect the construction of a new bituminous-surfaced highway, involving bridges, culverts, deep cuts, and high fills. The Chapter sent delegates to two sessions of the Alabama Section of the Society held in Birmingham and Montgomery. The activities included the presentation of student papers.

NORTHEASTERN UNIVERSITY

The period covered by the report has been one that has tested the Northeastern University Chapter's ability to carry on. We feel that we have been fortunate in continuing to function as a society in spite of the increasing difficulties caused by the war. Problems such as a loss of Chapter members, accelerated academic programs, lack of transportation for field trips, and difficulties in obtaining outside speakers have all been met effectively and enthusiastically. We, at Northeastern, have come to realize that the Student Chapter forms a definite and integral part of our civil engineering training program, and are determined to overcome all obstacles to hold our organization together. Our relationship with the Society has been extremely pleasant and we are fully aware of the many benefits that have accrued to us because of this association.

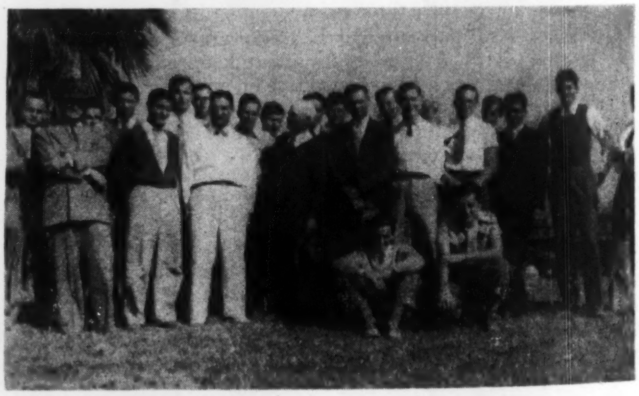
UNIVERSITY OF TENNESSEE

In spite of extraordinary conditions, including a considerable decrease in membership due to the war, the University of Tennessee Student Chapter has carried on in a manner comparable to that of previous years. The members have certainly been drawn closer together by existing circumstances, and the group enjoys a friendly fellowship that has not previously been so evident. The most unusual happening the Chapter experienced during the past eighteen months was the election by popular vote of the entire student body of one of its members to serve as one of four queens to preside over the Engineers' Ball and Banquet. Miss Betty Jo Sterling, the engineering queen, was one of three women members of the Chapter. As the new year gets under way, the Chapter eagerly looks forward to a year of even more and better activities. The membership will be smaller, but the spirit will continue.

TULANE UNIVERSITY

Notwithstanding the highly accelerated program of instruction instituted by the college because of the war, the Tulane University Student Chapter enjoyed a successful and profitable year. This meant extra effort on the part of all connected with the Chapter, since little time was available to the student after meeting his scholastic requirements. Through the courtesy of members of the Louisiana Section and others, Chapter members were able to participate in very interesting field trips, and to hear ten talks on timely engineering topics. A particularly interesting feature was that five of the addresses were presented by civil engineers, each of whom was an officer in one of five commissioned services—the Army, Navy, Coast Guard, Coast and Geodetic Survey, and Public Health Service.

The Chapter has tried to develop in its members a professional consciousness and a realization of their duties, both social and professional. As the college year drew to a close, however, it became more and more apparent that Chapter activities could not be continued on the customary plane because of the loss of students to the Armed Services and the necessary curtailment of extracurricular time. Thus it was felt advisable to adopt an inactive status for the war's duration, effective May 1, 1943. This step was taken reluctantly because the Chapter has been such a real and vital part of the lives of the civil engineering students at Tulane.



MEMBERS OF THE TULANE CHAPTER VISIT THE CONSOLIDATED AIRCRAFT PLANT

ITEMS OF INTEREST

About Engineers and Engineering

Engineers' Exploits in Invasion Lauded

In his broadcast of August 28, Raymond Gram Swing reviewed the contributions of the Army Corps of Engineers to the successful landings in Normandy on D-day, June 6. For those who may have missed the broadcast, extracts from the script, which Mr. Swing furnished for "Civil Engineering," are here printed.

It is not too early to look back to D-day itself, to the preparations for it, and the achievement of getting the foothold on the continent. All of that has receded in memory more than it deserves. If the Germans now whimper about Army betrayals and being outmatched in weapons, the Generals will go down in history as having mishandled the invasion, not because of any trouble in Berlin, or the initial weight of Allied material strength, but because they grossly underestimated what the Allies could do, breaking through the Atlantic Wall, and particularly what they could do in the way of putting supplies across the beaches. The Allies won, but the Germans lost, lost in straight military terms, by not reaching the best solution of their problem. I am saying this to lead up to an examination of the part played in the victory by the Corps of Engineers. For a notable part in the Allied success was the work of the engineers. It was work that began two years ago. It began in preparing the American bases in Britain, where more than 100,000 buildings were constructed or acquired in 1,100 English towns and villages. For the U.S. Army Air Force alone, enough railways, perimeter tracks, and hard standings were built to equal a 20-ft concrete highway from New York to Moscow.

To the engineers fell the task of preparing the maps for the invasion. No maps had been made of northwestern Europe, suitable for military operations, since the days of Napoleon. The engineers made maps, not by the thousands, but by the millions. They produced 16 millions for the invasion. They weighed 100 tons. There were battle maps as large as 2½ in. to the mile. For the beaches there were maps 12 in. to the mile. They made profile maps of the beaches, with tide charts so that one could tell just at what point a landing craft would touch bottom at any time of day.

They made maps of such accuracy as to distance and elevation that unobserved artillery fire could be carried out effectively at night as well as by day, something unknown till this war. They made exhaustive studies of 600 beaches from which the most suitable beaches for the D-day landings could be selected. They then trained their own combat engineers on replicas of the beaches chosen. These replicas were on the Devon coast, and here the combat engineers learned how to clear the beaches, destroy underwater obstructions, detonate mines, and get landed material into the interior.

The job of handling supplies and men across the beaches is the achievement on which to put the finger, for it was this which the Germans underestimated. The Germans assumed the Allies must have a port before the invasion could become a major operation. They also knew that Cherbourg was not such a port. Cherbourg in normal times could handle less than 800 tons a day, not enough for a single division, and 16 times less than Naples. To this day, the Allies have no other sizable port than Cherbourg, and it is an incredible element in the Allied campaign that they are operating where they are, still getting their supplies in the greater part across the beaches. This cannot continue indefinitely, for the weather will make the beaches unusable for continually longer periods. But so far, despite occasional bad weather, the Allied forces have never been left without supplies for a single minute.

The engineers are, of course, the road and bridge builders. It is nothing for them to lay half a mile of road in two hours, or for a single man with a scraper to remove more earth than 500 men in the same time could do with shovels. The engineers prepared detailed plans for the reconstruction of all ports, railways, roads, and public utilities in the areas attacked by the American armies. Much of the material, such as heavy railway bridging, was ordered almost two years ago. Accurate requisitions for lumber, reinforcing steel, rails, wire, structural steel, and construction equipment were stockpiled in Britain before the invasion. They not only prepared to bridge the streams, they themselves made the river crossings for advancing troops, using assault boats and rafts, and finally building fixed or floating bridges.

One of their services is to construct the facilities and distribute gasoline and lubricants. When General Patton's army swings around to the south of Paris, rushing forward so swiftly that one can almost see it move on a small map, the engineers must be behind him, prepared to see that he gets its fuel. And they can build pipe lines at a speed of 20 miles of 4-in. pipe a day, and 10 miles of 6-in. pipe a day. It would be wrong to call this an engineer's war, and give the engineers all the glory of the Normany victory. But they have more than earned their full share of the credit.

A.S.A. Guide to Building Code Arrangement

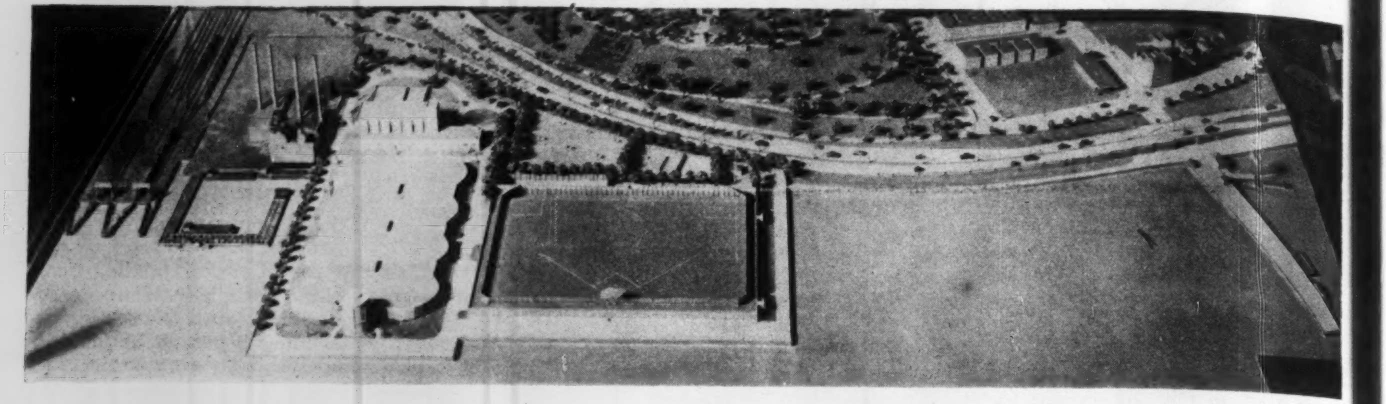
The Building Code Correlating Committee of the American Standards Association had drawn up a code arrangement, as an integral part of its building code standardization work, which is planned to serve as a guide to any groups developing building code requirements. The arrangement is presented for the use of municipal committees and public officials in connection with the preparation and revision of local building codes. It outlines a complete and coordinated series of standard building requirements. Some of the standards in this series are already approved and in use; others are in the process of development.

The arrangement covers every phase of building from administration to plumbing, divided into 17 chapter headings. Under each of these headings are detailed lists of subjects to be covered. The order of the chapter titles is subject to change, but in general is in agreement with the planning of the Building Code Correlating Committee and the technical committees developing the specific standards. Among the chapter headings are the following: general building limitations, special occupancy requirements, construction requirements, and fire-extinguishing equipment.

The standards already completed and available are:

Fire Tests of Door Assemblies (A2.2-1942), 25 cents
Portable Steel and Wood Grandstands (Z20.1-1941), 60 cents
Building Code Requirements for Reinforced Gypsum Concrete (A59.1-1941), 25 cents
Fire Tests of Building Construction and Materials (A2.1-1942), 25 cents
Building Exits Code (A9.1-1942), $1.00
Building Code Requirements for Structural Steel (Riveted, Bolted or Welded Construction) (A57.1-1943), 40 cents
Building Code Requirements for Masonry (A41.1-1944), 50 cents
Administrative Requirements for Building Codes (A55.1-1944), 35 cents
Safety Code for Elevators, Dumbwaiters and Escalators (A17.1-1937) with Supplement (A17.3-1942), $1.25
National Electrical Code (C1.-1940), 5 cents
Safety Code for Mechanical Refrigeration (B9-1939), 20 cents

The Building Code Arrangement, for which there is no charge, and any of the preceding standards at the prices quoted, may be ordered from the American Standards Association, 70 East 45th Street, New York, N.Y.



MODEL OF OWL'S HEAD SEWAGE DISPOSAL PLANT, BASEBALL FIELD, AND PLAYGROUND
In New York City's Exhibit of Postwar Public Works

Exhibit of Postwar Public Works

SOME new and important developments now form part of New York City's Exhibit of Postwar Public Works. In addition to the many drawings, perspectives, models, and maps which were in the exhibit when it first opened in May 1944, there are now included a diorama of the unique Oceanarium to be constructed at Coney Island, models of the Marcy Housing project in Brooklyn, the Harlem River Drive in Manhattan, and a novel vehicular ramp connection between Queensboro Bridge and Welfare Island. Other perspectives and drawings, now included or to be added shortly, show completed or advanced plans for the many projects in the city's $1,250,000,000 program, including the new designs for the large airport at Idlewild, Borough of Queens.

Considerable progress has been made in the architectural and engineering plans for a large percentage of the projects in the program. An interesting chart has been prepared showing the percentage of projects in various stages of plan completion, together with a departmental summary of the amounts allocated for various improvements and a brief indication of the proposed methods of financing the entire program.

The exhibit occupies the lower floor of the building at 500 Park Avenue, in Manhattan. The central feature is a large floor model of New York City on which all the projects in the postwar program are shown by colored, three-dimensional symbols. From a semicircular ramp, visitors look down on the diagrammatic map of the metropolis, presenting a general panorama of the city as it might appear from the air. The main purpose of this map is to show the distribution of the improvements over the city as a whole, and to emphasize the geographical relationships of the different sections, which are to be more closely unified by new and improved express highways, rapid transit, bridges, and other city-wide facilities and services.

Visitors may locate local neighborhood projects for schools, playgrounds, parks, hospitals, libraries, health centers, and other types of public buildings and facilities designed to improve standards of city living. The remainder of the exhibit has been arranged on a geographical basis, providing separate sections for each of the five boroughs, where details of many of the local projects are shown by models, drawings and other graphic presentations.

This ambitious exhibit indicates that advances are being made continuously in planning for postwar work. Other communities are similarly active. Progress, while not as extensive as it should be, is nevertheless real, and in the direction so long advocated by the Society and its Committee on Postwar Construction.

N. G. Neare's Column

Conducted by

R. ROBINSON ROWE, M. AM. SOC. C.E.

"MR. G. C. BERRY
Secretary, Engineers Club
Esseyeville, U.S.A.

"DEAR MR. SECRETARY: As you know, I will be en route to the Local Sections Conference in Denver at the time of the October Meeting.

"Will you help me by asking any cribbage players present two questions: (1) 'What are the probabilities for occurrence of His Nobs and His Heels in 2-hand cribbage?' and (2) 'If Lt. Nobs Nobmann pegged one for every His Nobs, how could the bottom card of the deck determine fairly the holes to be pegged by Lt. Heels Heald for every His Heels?'

"If any answer agrees with my postscript, don't read it, but dictate the new problem on the attached sheet.

"Thanks. (S) NOAH"

Secretary Berry, having read the above, looked over the Club expectantly.

"I can answer the first, but the second doesn't make sense," said Joe Kerr. "Since the cut is just as likely to find a jack as any other spot, the probability of His Heels is $^1/_{13}$. The probability of a jack in the 12 cards dealt is 12/13 and of the jack's suit being cut is 1/4, so the probability of His Nobs is $12/13 \times 1/4 = 3/13$.

"So His Heels occurs $^1/_3$ as often as His Nobs and should count 3 times as much. So Heald could peg 3 regardless of the bottom card! So what?"

Ken Bridgewater agreed, adding, "Titus Wadhouse and I played 104 games to check my analysis. We recorded 8 His Heelses and 23 His Nobses, which seems to clinch it. Maybe it was too simple for Heald to peg 3 for each His Heels; maybe he pegged 6 if the bottom card was red, or 12 if it was a spade. There are many solutions like that."

"Apparently I'll have to read the postscript," said the Secretary. "It's rather cryptic.

"Probability of His Heels is 1/13. If cut is not a jack, the jack of the suit cut may be in any of 51 places—12 in the deal and 39 in the pack. Chance of its having been dealt is 12/51 = 4/17. So probability of His Nobs is $12/13 \times 4/17 = 48/221$.

"Then in 221 deals there will be 48 His Nobses and 17 His Heelses, each group to count 48 holes. Let 16 of the latter peg 3 each and the 17th nothing. When His Heels is cut, chance of one of the other jacks being on the bottom is 3/51 = 1/17. So Lt. Heald pegged 3 for His Heels except when another jack was on the bottom."

Joe Kerr rose to argue, but the Secretary waved him down. "Hold it until Noah gets back. Now here's his new problem.

"Titus Wadhouse has been drinking his coffee bitter all year, saving cube sugar for an Xmas present to his sugar-toothed son in the Sea Bees. Being an Efficiency Engineer, he made up his package for maximum cubage of unbroken cubes, obeying the postal restrictions: maximum length, 15 in.; maximum girth plus length, 36 in. Cubes were 0.6 in. on each edge; thickness of each wall of the package was 0.2 in. How many cubes were packaged?"

[*Cal Klater must be on a vacation, as no correct answer was received before the deadline. Joe Kerr's were numerous. Correct solutions to the problem of Rollo's Boudoir came a few days late from vacationers Lynne Bevan and O'Kay (Otto H. S. Koch). The new problem may sound too practical for this column. It isn't. The postmaster sent Titus home to reduce the weight to 5 lb. before October 15.*]

University Library Receives Welding Award Papers

Recently the Welding Library at Ohio State University has added to its collection 75 bound volumes containing the papers submitted in the 1937–1938 James F. Lincoln Arc Welding Award Program. Over seven hundred papers, covering the application of welding to practically every product and structure, are included. Some of these papers have appeared in Civil Engineering in somewhat condensed form.

The papers add substantially to the wealth of welding information in this collection, which was presented to the University in 1942 by A. F. Davis, an alumnus.

The library contains approximately 1,000 books on designing for welded construction, welding techniques and procedures, properties of weld metals, standard welding handbooks, metallurgy; also magazine articles, technical papers, patents, and other literature contributing knowledge on the subject of welding. Copies of some seven thousand patents concerning welding equipment and the patented applications of welding to products or structures are now on file.

Engineers, industrial designers, technicians, production men, shipbuilders, and others interested in research or general information on welding and its application to construction, manufacture, or maintenance of metal structures, are welcome to use the facilities of this library. It is located in the Industrial Engineering Building, Ohio State University, Columbus, Ohio.

A Long Record of Service

Edwin A. Fisher, Hon. M. Am. Soc. C.E., is known among engineers not only for his professional eminence but for his long continued service. He is reported to be active in his office at the city hall in Rochester, N.Y., every week day except Saturday. Recently, on the occasion of his 97th birthday, he was the honored guest of his colleagues at luncheon.

NEWS OF ENGINEERS

Personal Items About Society Members

C. C. Williams has severed his connection as president of Lehigh University in order to establish a general practice as consultant in engineering and industrial education at Madison, Wis. Dr. Williams will specialize in departmental and institutional surveys, industrial cooperative researches, and in training industrial personnel, with special reference to postwar adjustments.

R. G. Sturm, formerly research engineer physicist for the Aluminum Company of America at New Kensington, Pa., is now at Purdue University in the capacity of professor of engineering mechanics and research professor of materials in the Engineering Experiment Station there.

E. B. Myott, lieutenant colonel, Corps of Engineers, U.S. Army, has been granted the Legion of Merit Award for "exceptionally meritorious conduct in the performance of outstanding service" with the Persian Gulf Service Command. He was in responsible charge of various port and motor transportation facilities, and served as chairman of the Inter-Allied Committee on Traffic Control. The award was presented at the Army Service Training Center at Camp Claiborne, La., where he was assigned following his overseas duties. In civilian life he was principal engineer for Fay, Spofford and Thorndike, of Boston, Mass.

Robbert S. Taggart, first lieutenant, Sanitary Corps, U.S. Army, succeeds Capt. David S. Smallhorst in the Sanitary Engineering Division, Preventive Medicine Service, Office of the Surgeon General. He was formerly district sanitary engineer for the New York State Department of Health.

Lloyd R. Wilson, of Montclair, N.J., has resigned as vice-president and director of the Ransome Machinery Company, of Dunellen, N.J., a subsidiary of the Worthington Pump and Machinery Corporation, and has terminated his connection with the company.

Robert B. Rhode has been promoted to the position of assistant engineer in the bridge department of the Northern Pacific Railway Company, with temporary headquarters in Missoula, Mont. He will be engaged in the field on the reconstruction and strengthening of bridges.

Robert K. Brown, secretary for the Utah State Council of Defense, was recently presented with a sterling silver life membership card, following his election for the twenty-fifth consecutive year as treasurer of the Utah Society of Professional Engineers. Mr. Brown was for many years chief engineer of the Salt Lake and Utah Railroad.

John A. Shaw, captain, Corps of Engineers, U.S. Army, has been retired from the Army because of having reached the age limit. Mr. Shaw, who has been serving as post engineer at the Presidio of Monterey, will take up residence at Claremont, Calif.

S. S. Steinberg, head of the college of engineering at the University of Maryland, has been appointed engineer adviser to the State Aviation Commission of Maryland. In this capacity he will direct engineering studies of existing and proposed airports throughout the state, in order to fit each community into the proposed nation-wide airways plan.

Charles Ernest Ramser has been awarded the John Deere Medal of the American Society of Agricultural Engineers, which was established and endowed in 1937 "to acclaim distinguished achievement in the application of science and art to the soil." Mr. Ramser has been connected with the U.S. Department of Agriculture since 1913—for the past two years in the capacity of research specialist in hydrology for the Soil Conservation Service.

George A. Gregory, construction engineer on Alder Dam and Powerhouse, has been promoted to the position of civil and hydraulic construction engineer in charge of the Second Nisqually Power Development for the City of Tacoma.

Sidney Weniger is now an ensign in the U.S. Naval Reserve. Prior to receiving his commission he was assistant naval architect in the Development of Design Division of the New York Navy Yard, Brooklyn, N.Y.

Julian Montgomery, Austin (Tex.) consultant, has been engaged by the City Commission of Temple, Tex., to prepare a master plan for the development of the city for the next fifteen years.

James A. Lindsey was recently promoted from the rank of ensign in the Civil Engineer Corps of the U.S. Naval Reserve to that of lieutenant (jg). Lieutenant Lindsey is, at present, stationed in the New York City area.

Odd Albert, structural engineer of Belmar, N.J., has joined the staff of Gannet, Fleming, Corddry and Carpenter, Inc., engineers of Harrisburg, Pa.

W. D. Faucette, for over thirty years chief engineer of the Seaboard Railway, with headquarters at Norfolk, Va., has been promoted to the position of executive representative.

Anton E. Tedesko has returned to the main office of the Roberts and Schaefer Company in Chicago, after serving for the past two years as engineering manager for the Eastern branch office in Washington.

N. W. Haner, lieutenant colonel, Corps of Engineers, U.S. Army, has been transferred from the U.S. Engineer Office at Providence, R.I., to the Engineer Office at Wilmington, N.C., where he will serve as acting district engineer. Colonel Haner recently returned from an overseas assignment.

Clarence Rawhouser, civil engineer for the U.S. Bureau of Reclamation at Denver, Colo., has been given the "award of excellence" of the Department of the Interior for developing a method of eliminating concrete construction joints, which effects tremendous savings in the building of dams.

Earle L. Waterman, professor of sanitary engineering at the University of Iowa, was recently appointed head of the department of civil engineering there. He succeeds **B. J. Lambert**, who retired a few months ago.

Joseph B. Tiffany, Jr., has been promoted from the rank of lieutenant in the Corps of Engineers, U.S. Army, to that of captain. He is stationed at Vicksburg, Miss., where he is executive assistant to the director of the U.S. Waterways Experiment Station.

Earle B. Butler, major, Corps of Engineers, U.S. Army, has been transferred from Memphis, Tenn., to Atlanta, Ga., where he is engineer supply officer in the Army Service Forces Depot.

Wilson V. Binger, who was commissioned a second lieutenant in the Corps of Engineers at the Officer Candidate School at Fort Belvoir in August, has been assigned to the Engineer Officers Reserve Corps Army Service Forces Training Center, Fort Lewis, Wash.

F. T. Mavis is now professor and head of the department of civil engineering at the Carnegie Institute of Technology at Pittsburgh, Pa. He was formerly head of the civil engineering department at Pennsylvania State College.

Thorndike Saville, dean of the college of engineering at New York University, was recently honored with an award from the Army Air Forces Training Command for the excellence of his work in meteorological training.

James B. Hays is now in Palestine on irrigation and drainage work, continuing the studies on which he was recently engaged in New York City.

Claude R. Zimmerman, Jr., of Byron, Okla., a navigator on a Liberator Bomber, has been awarded the Air Medal "for meritorious achievement in aerial flight while participating in sustained operational activities against the enemy." He was commissioned a second lieutenant in the Army Air Force at Rondo, Tex., in February 1944 and is now stationed with a bombardment group somewhere in Italy. At the time of his enlistment Lieutenant Zimmerman was a member of the Student Chapter at the Oklahoma Agricultural and Mechanical College.

DECEASED

Edward Franklin Berry (M. '29) head of the civil engineering department at Syracuse University, Syracuse, N.Y., died in that city on August 28, 1944. He was 54. Professor Berry taught at Lafayette College and Lehigh University and held engineering posts with railroads in Canada and the United States before joining the Syracuse University staff in 1920. He was, successively, assistant professor, associate professor, and professor of civil engineering there, and from 1923 to 1939 was director of the university's materials testing laboratory. He specialized in the design of apparatus for testing the permeability of concrete and was the author of numerous works on that and kindred subjects.

Sherman Worcester Bowen (M. '12) until recently vice-president of the Fruin-Colnon Contracting Company, of St. Louis, Mo., died on August 19, 1944, at the age of 67. From 1901 to 1914 Mr. Bowen was with Brenneke and Fay, St. Louis consultants, on the construction of the Municipal Bridge across the Mississippi, and from 1914 to 1916 he was field engineer in the water department of the City of St. Louis. In the latter year he became connected with the Fruin-Colnon Contracting Company, serving as vice-president from 1927 until a few weeks ago when illness forced his retirement.

Mortimer Elwyn Cooley (M. '11) Honorary Member of the Society and former Director, died in Ann Arbor, Mich., on August 25, 1944, at the age of 89. He had been a member of the faculty at the University of Michigan for forty-seven years, and dean of the colleges of engineering and architecture for twenty-five years. At the time of his death he held the title of dean emeritus. A brief biography and photograph of Dean Cooley appear in the "Society Affairs" section of this issue.

Samuel Morrison Ellsworth (M. '29) consulting engineer of Boston, Mass., died at Brattleboro, Vt., on August 13, 1944. His age was 49. Mr. Ellsworth was with Morris Knowles, Inc., of Pittsburgh, Pa., from 1920 to 1921; with Weston and Sampson, consulting engineers of Boston, from 1922 to 1923; with the North Jersey District Water Supply Commission from 1923 to 1926; and with Metcalf and Eddy, Boston consultants, from 1926 to 1932. In 1933 he entered private practice, specializing in the fields of water supply, sewage, waste disposal, and general sanitation. During the first World War Mr. Ellsworth served as a lieutenant in the 26th Engineers with the A.E.F.

Berthold Francis Hastings (M. '22) district engineer for the American Institute of Steel Construction, Philadelphia, Pa., died in a hospital in that city on August 11, 1944. Mr. Hastings, who was 55, had been connected with the American Institute of Steel Construction for a number of years. Earlier he had taught at Yale and the University of Pennsylvania, and for a time was with the U.S. Reclamation Service (now the Bureau of Reclamation). Mr. Hastings had, also, been associated with the H. G. Balcom Engineering Company in New York.

Verne Le Roy Havens (M. '13) retired engineer of Jackson Heights, N.Y., died in New York City on August 12, 1944. Mr. Havens, who was 63, had built railroads in the United States, Mexico, and Spain, and street railway systems in San Francisco and Havana, Cuba. He constructed the Mexico City municipal power plant, a project involving unique foundation problems, and was project engineer for the huge irrigation and power project at Hastings, Nebr. He was the author of a number of technical books in Spanish, including a text on railway engineering.

Harry Hamilton Holton (Jun. '41) lieutenant, Air Corps, U.S. Army, was killed in an airplane crash at Kunming, China, on July 10, 1944, while on duty with the American Transport Command. He was 23. Following his graduation from Mississippi State College in the class of 1941, Lieutenant Holton became connected with the Tennessee Valley Authority. He received his "wings" at Spence Field, Moultrie, Ga., in January 1943, and was sent overseas the following June. He recently received a Presidential Citation for "meritorious service" and was promoted to the rank of first lieutenant.

Elmer Thomas Howson (M. '20) vice-president and director of the Simmons-Boardman Publishing Corporation, Chicago, Ill., died on September 1, 1944. Mr. Howson, who was 60, spent his early career in railroad work. In 1911 he joined the editorial staff of *Railway Age*, and since 1919 he had been Western editor. Coincidentally, for most of this period, he was also editor of *Railway Engineering and Maintenance*, and vice-president of the Simmons-Boardman Publishing Corporation.

Thomas David Hunt (Jun. '41) of Berkeley, Calif., was killed in the Port Chicago explosion in California on July 17, 1944, while employed as field engineer for the Macco Construction Company on the building of piers for the Navy. He was 25. Following his graduation from the University of California in 1941, Mr. Hunt was for two years junior engineer for the U.S. Engineer Office at Sacramento.

Edward Rowland Lewis (M. '13) retired engineer of St. Petersburg, Fla., died at his home in that city on August 13, 1944, at the age of 74. Until his retirement a few years ago Mr. Lewis lived in Detroit, Mich., where he was principal assistant engineer for the Michigan Central Railroad. Earlier in his career he was engaged on the rehabilitation of the Duluth, South Shore and Atlantic Railway, and on improvement of the South African railways.

John Francis Minihan (Assoc. M. '27) of San Francisco, Calif., died on August 14, 1944, at the age of 47. From 1919 to 1920 Mr. Minihan was with E. O. Burgess, San Francisco consultant; from 1920 to 1922, engineer for the Pacific Coast Steel Company, of San Francisco; and from 1922 to 1932, estimator for Cahill Brothers, Inc., contracting engineers of San Francisco.

Horace Ropes (M. '03) retired civil engineer of Minneapolis, Minn., died on September 3, 1944. For much of his career Mr. Ropes was engaged in engineering work in Minneapolis. In 1938 illness caused by injuries received in an automobile accident forced his retirement.

Rupert Kennedy Stockwell (M. '18) district manager for the Robins Conveying Belt Company, of San Francisco, Calif., died at his home in Oakland on August 24, 1944. Mr. Stockwell, who was 62, had been with the Robins Conveying Belt Company since 1918—from 1920 to 1934 as head of the London branch, and from 1934 to 1937 as head of the company's office in Shanghai. Since the latter year he had held a similar post in San Francisco. Earlier in his career he served as construction engineer for the U.S. Smelting and Refining Company, and from 1912 to 1917 he was chief engineer for the Braden Copper Company at Rancagua, Chile.

John Sweeney (M. '30) consulting engineer of Paris, Tenn., died there on August 16, 1944. Mr. Sweeney, who was 58, spent his early engineering career in Canada—successively, as district engineer for the Public Works of Canada at Winnipeg; supervising engineer on the construction of Toronto Harbor improve-